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Founder & CTO

DoE SSL R&D Workshop
28 January 2014

1.

The Conventional Wisdom

(and where it's not quite correct)

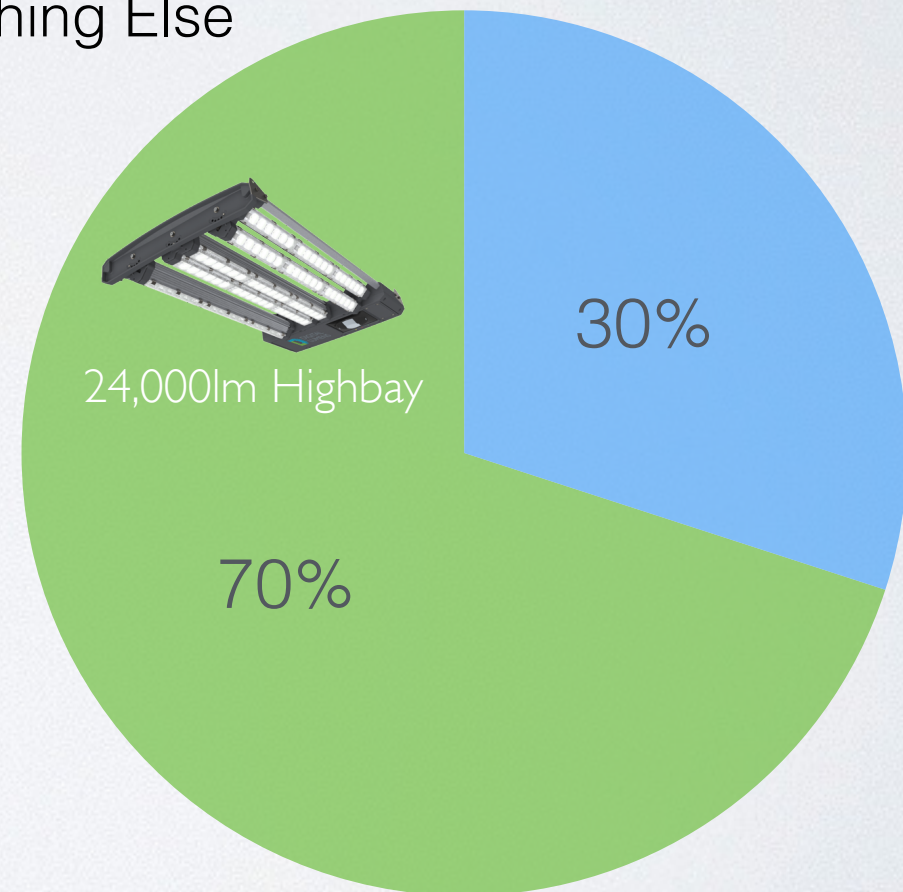
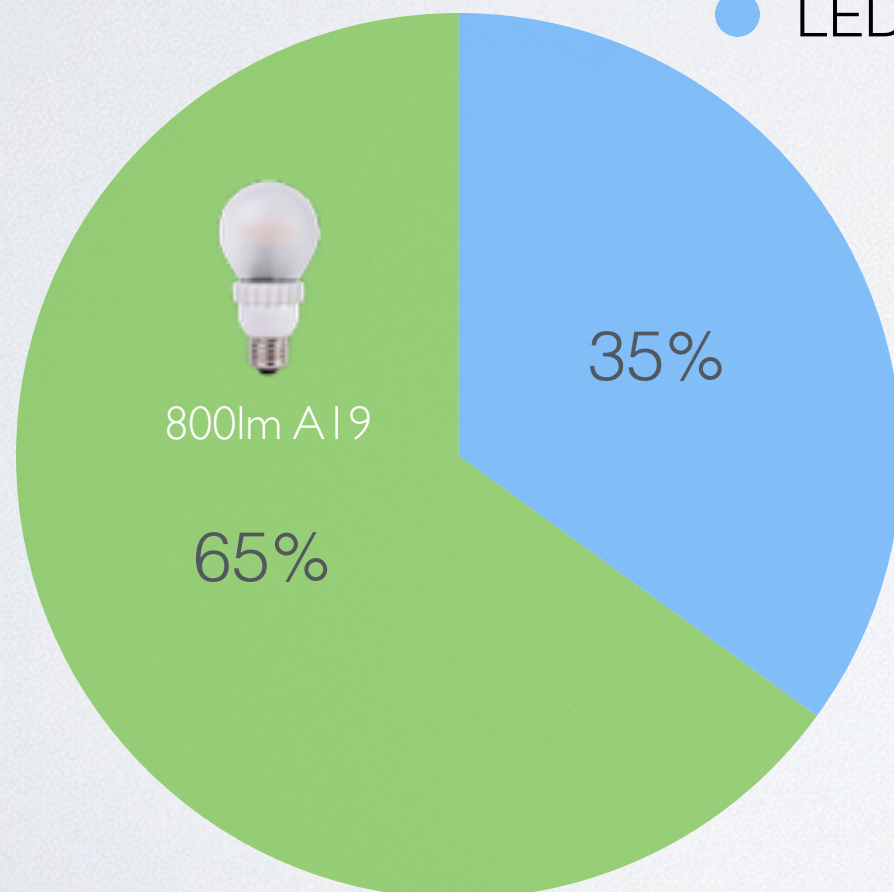
Cost

CLAIM: LEDs are getting so cheap, so quickly, that the revolution is inevitable.

REALITY: Balance-of-system costs already dominate. Even if LED cost goes to zero, there's a lot of work to do in order to match the initial cost of incumbent technologies.

Material Cost Breakdown

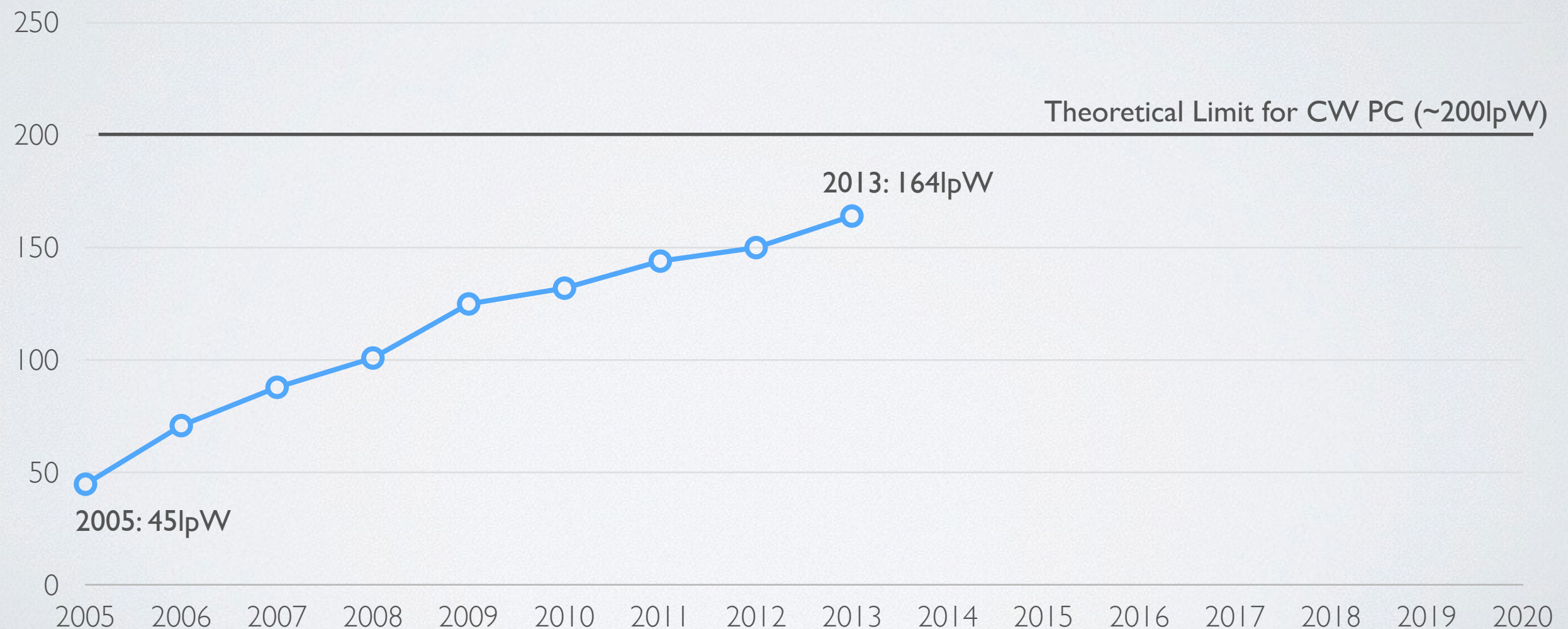
● LEDs ● Everything Else



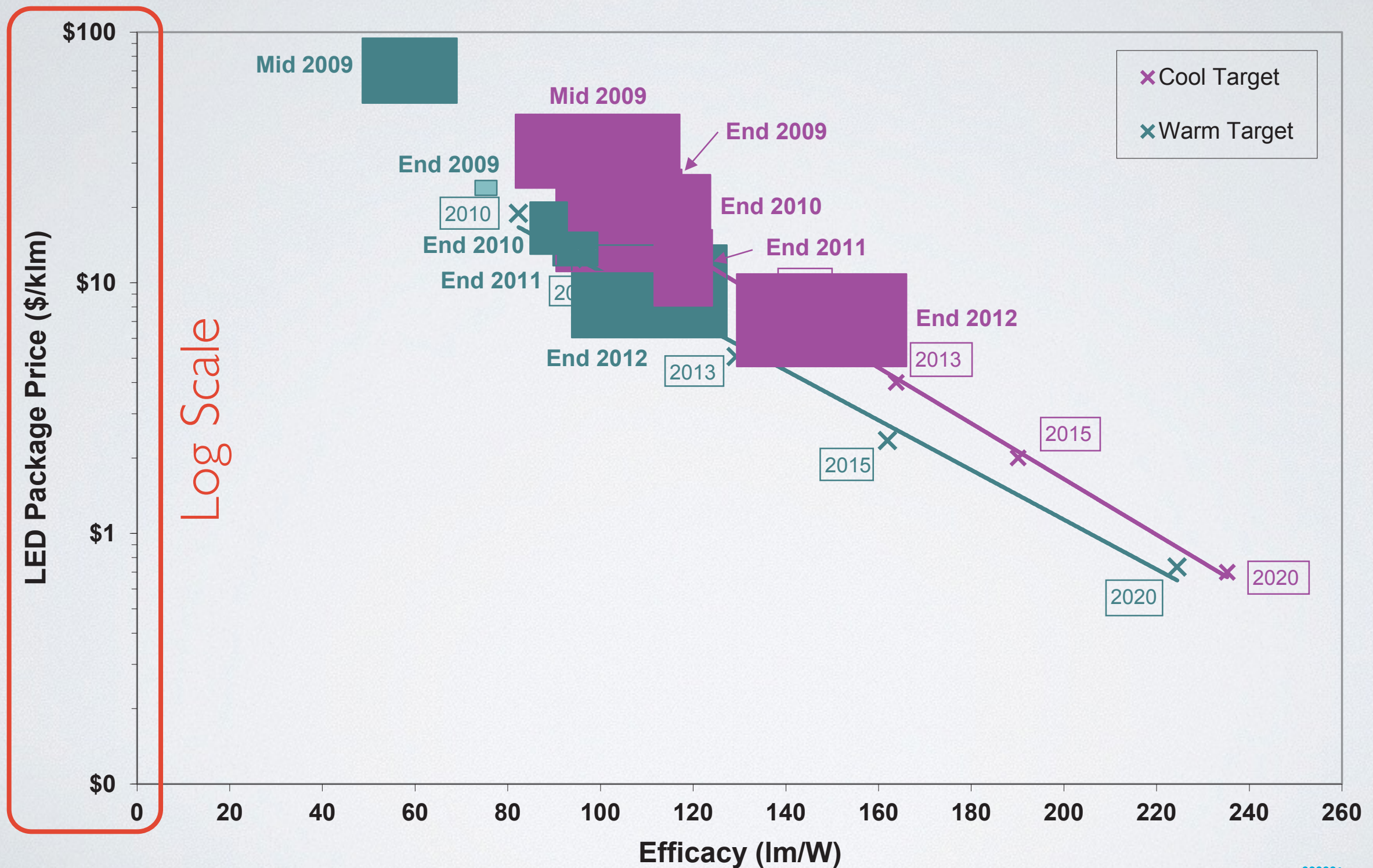
Efficacy

CLAIM: Ever-increasing LED efficacy will simply overwhelm incumbent technologies.

REALITY: Over the past decade, we have already realized most of the possible efficacy gains.



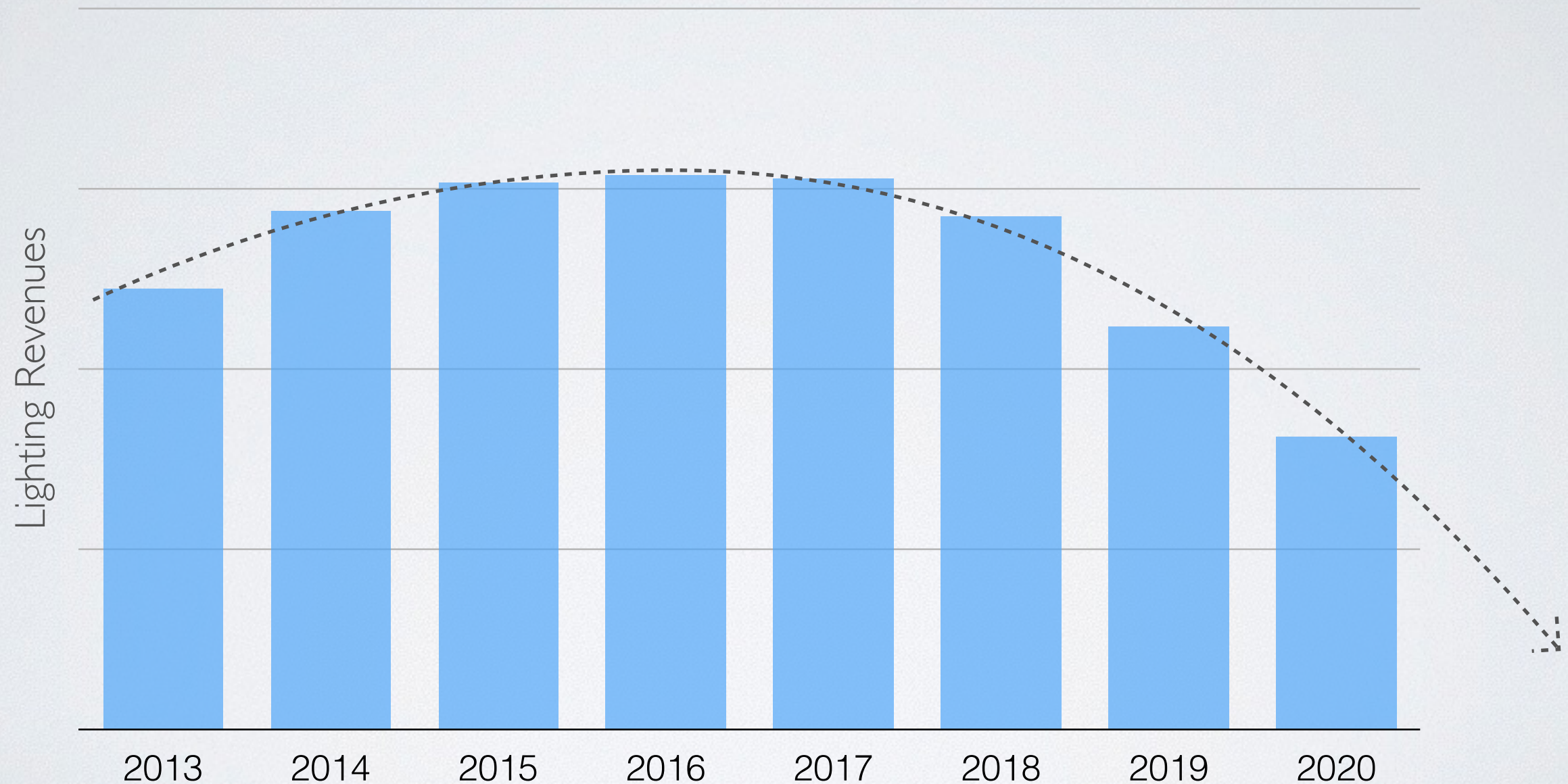
Beware the Asymptotes...



Socket Saturation

CLAIM: Since LEDs “last forever”, we will see a surge of adoption followed by a contraction.

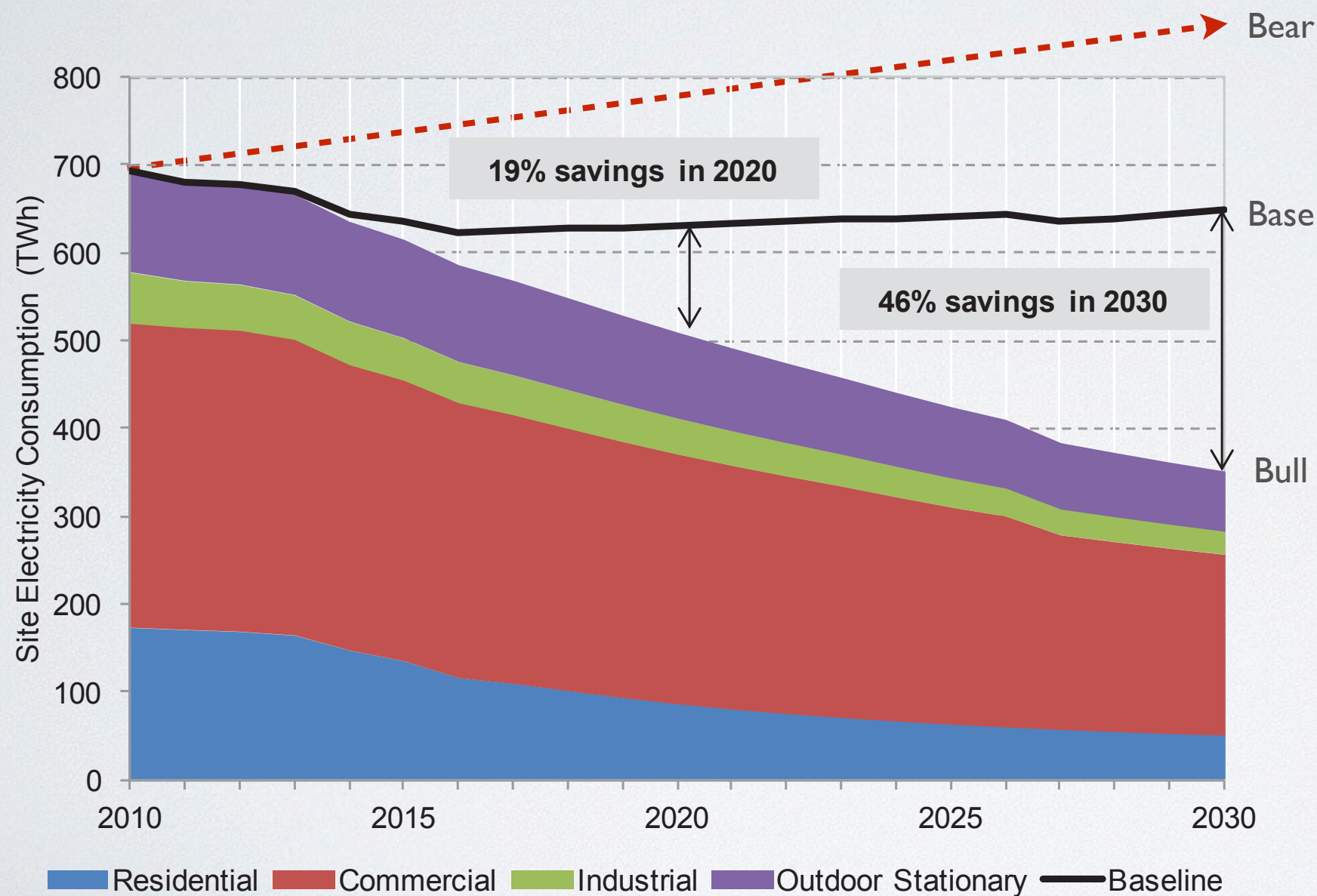
REALITY: Seems unlikely, for a variety of reasons.



Jevons Paradox

CLAIM: As lighting gets more efficient, we will use more of it.

REALITY: To some extent this is true. But the digital, controllable nature of LEDs provides a counterbalance.



In *The Coal Question* (1865), William Stanley Jevons maintained that technological efficiency gains—specifically the more “economical” use of coal in engines doing mechanical work—actually increased the overall consumption of coal, iron, and other resources, rather than “saving” them, as many claimed.

-Alcott, Blake (July 2005). "Jevons' paradox".
Ecological Economics 54

Value Chain Collapse

CLAIM: As with most other semiconductor technology, value will accrue downstream.

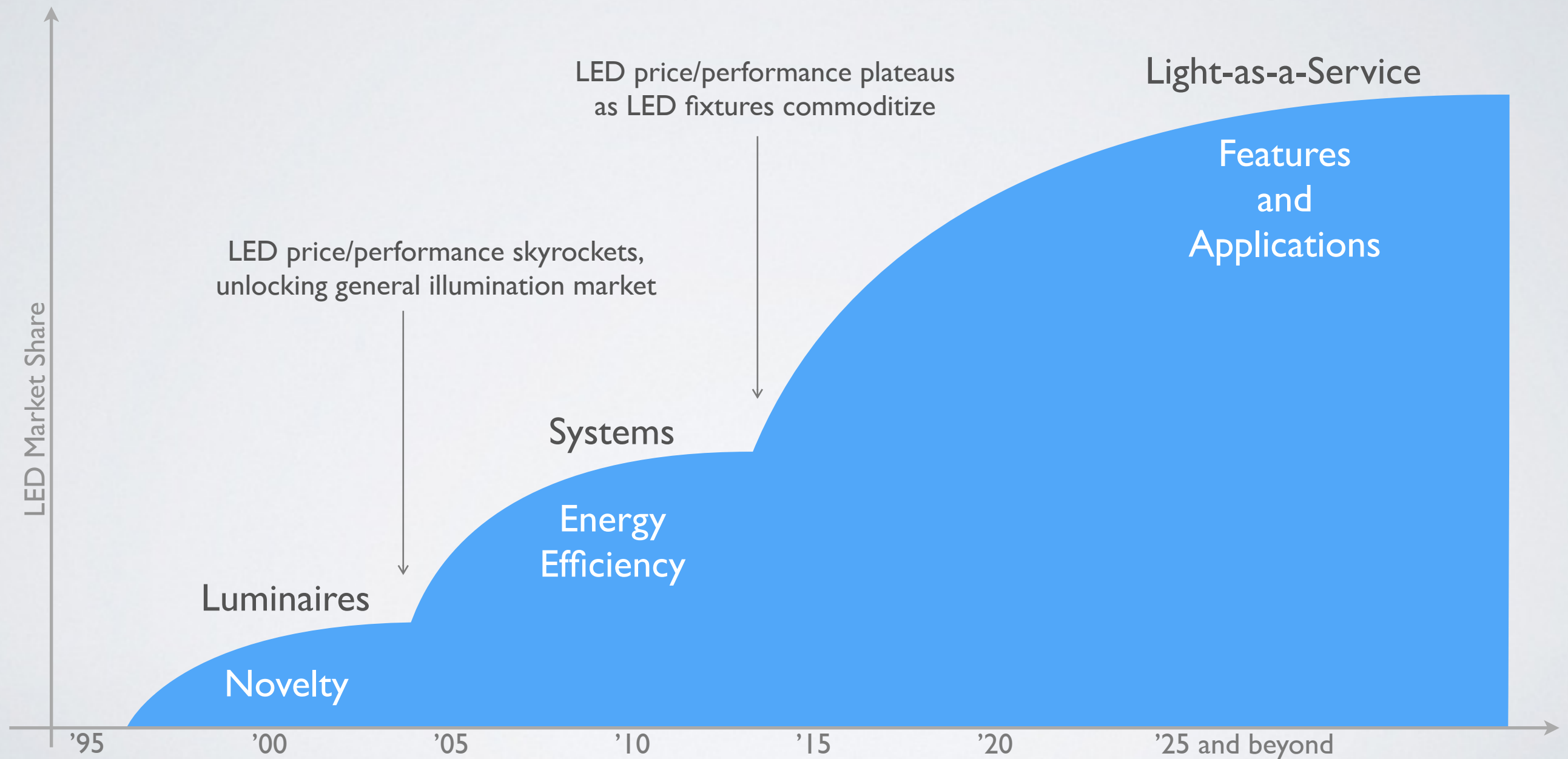
REALITY: Probably true. So what do we do about it?



- Upstream commoditization benefits downstream providers
- Access to channel and customers drives growth
- Features (not just photons) build market share

The Third Wave

(the future of lighting is **digital**)



2.

Where we are headed
(intelligent lighting unlocks new markets)



Industrial



Hospitality



Residential



Retail

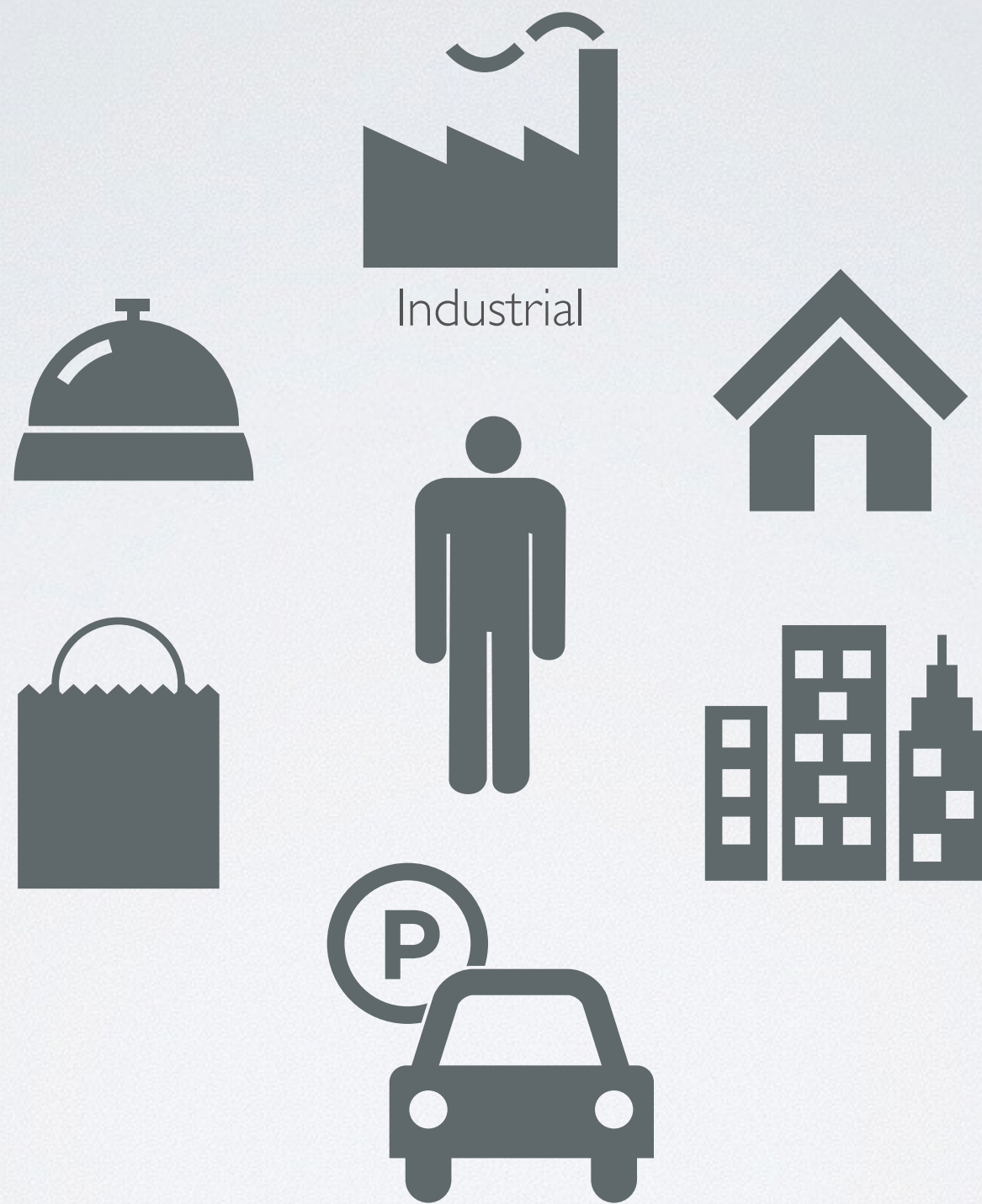


Parking



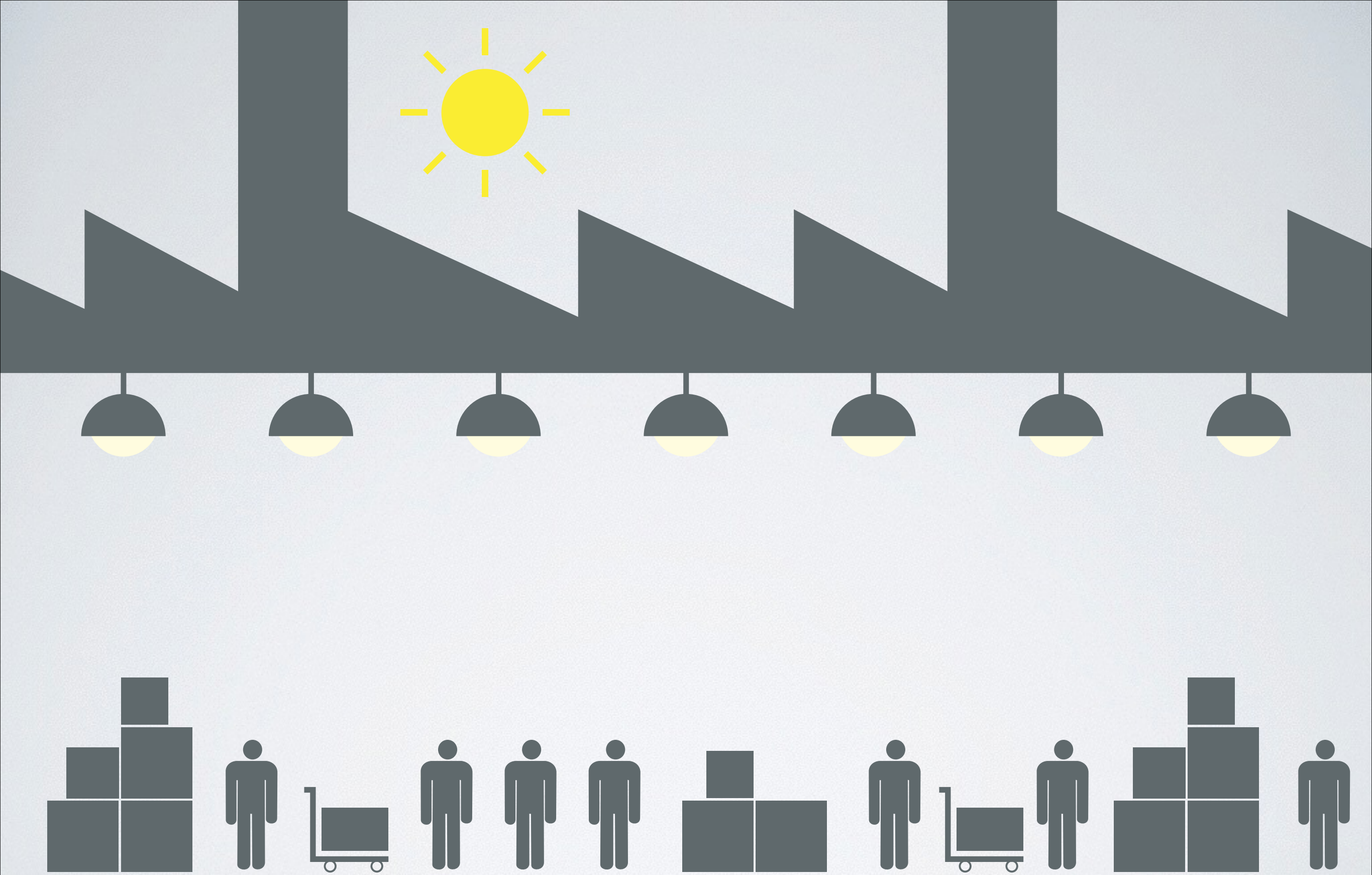
Office

Intelligent Lighting will be everywhere

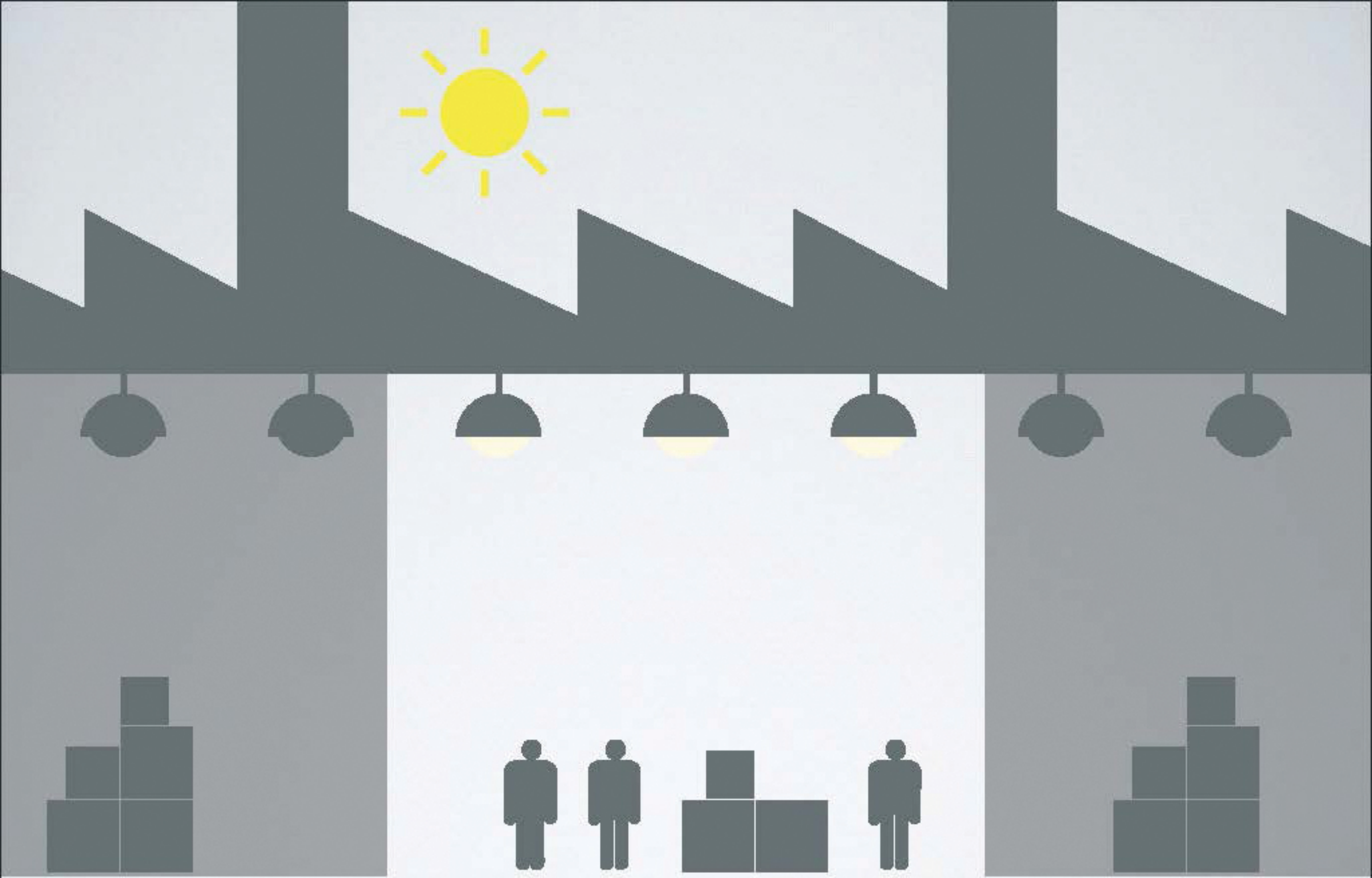




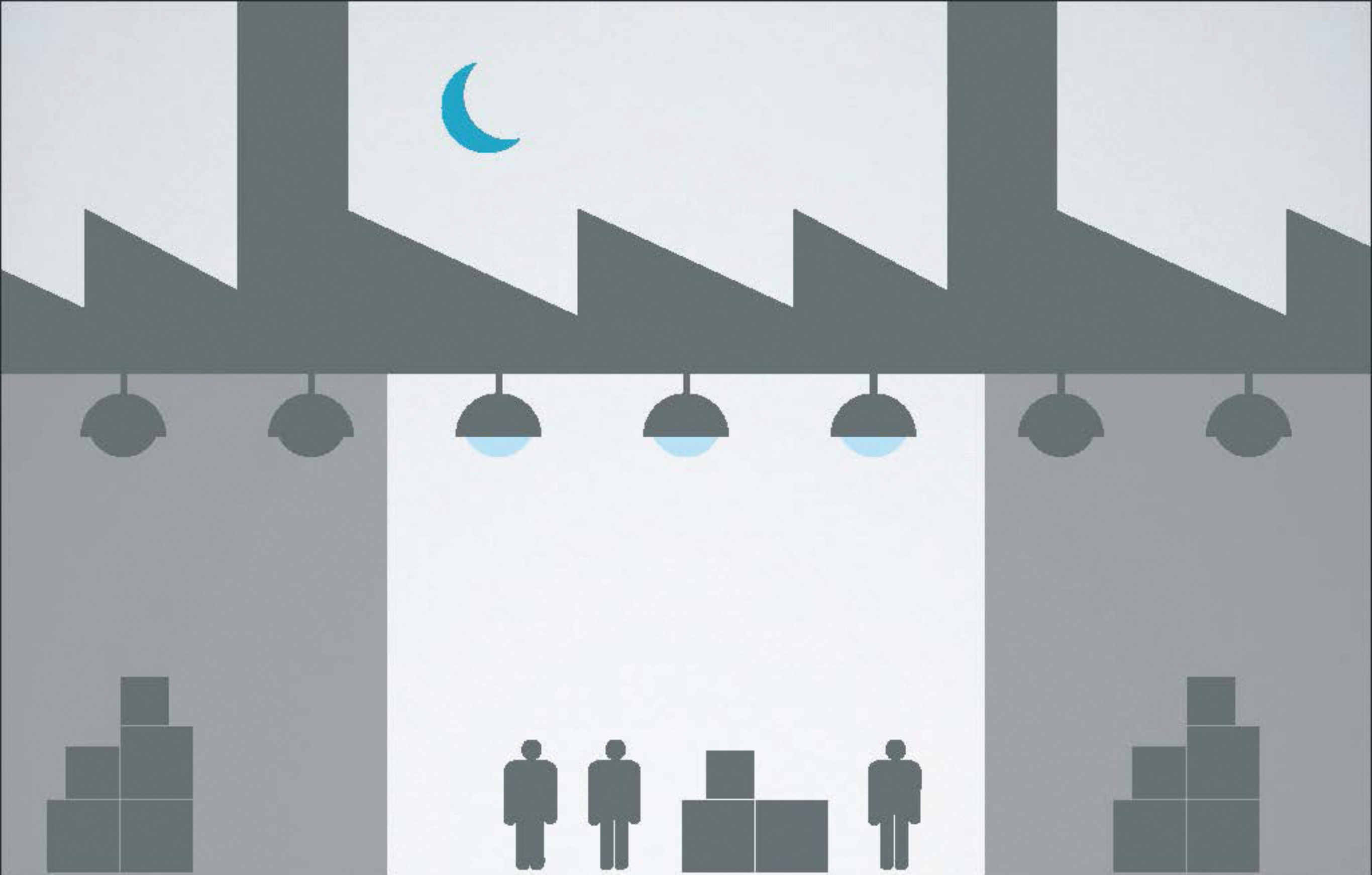
Intelligent **Industrial** Lighting



Intelligent **Industrial** Lighting



Intelligent **Industrial** Lighting



Intelligent **Industrial** Lighting



Intelligent **Industrial** Lighting

Intelligent **Industrial** Lighting

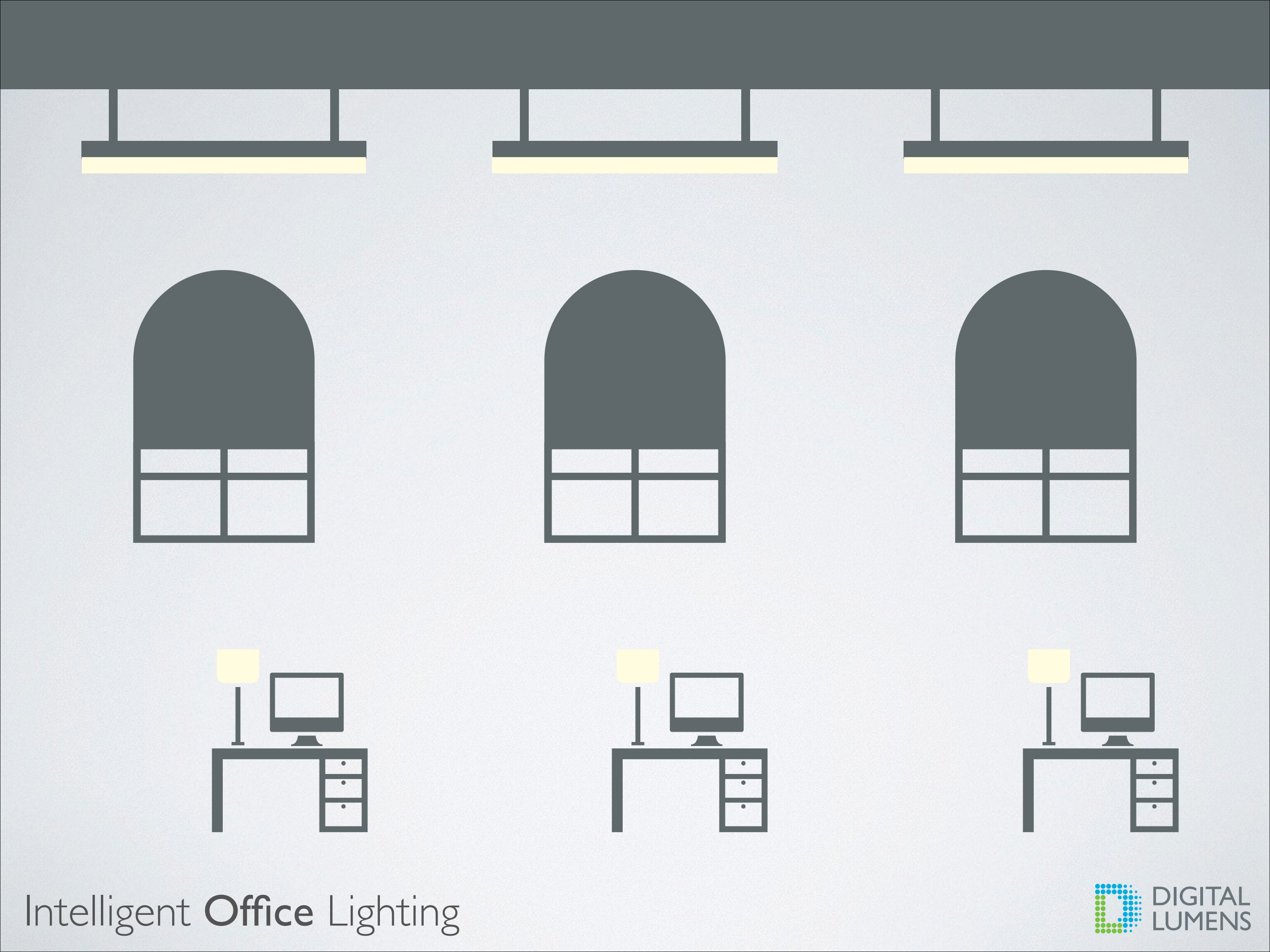
to enhance

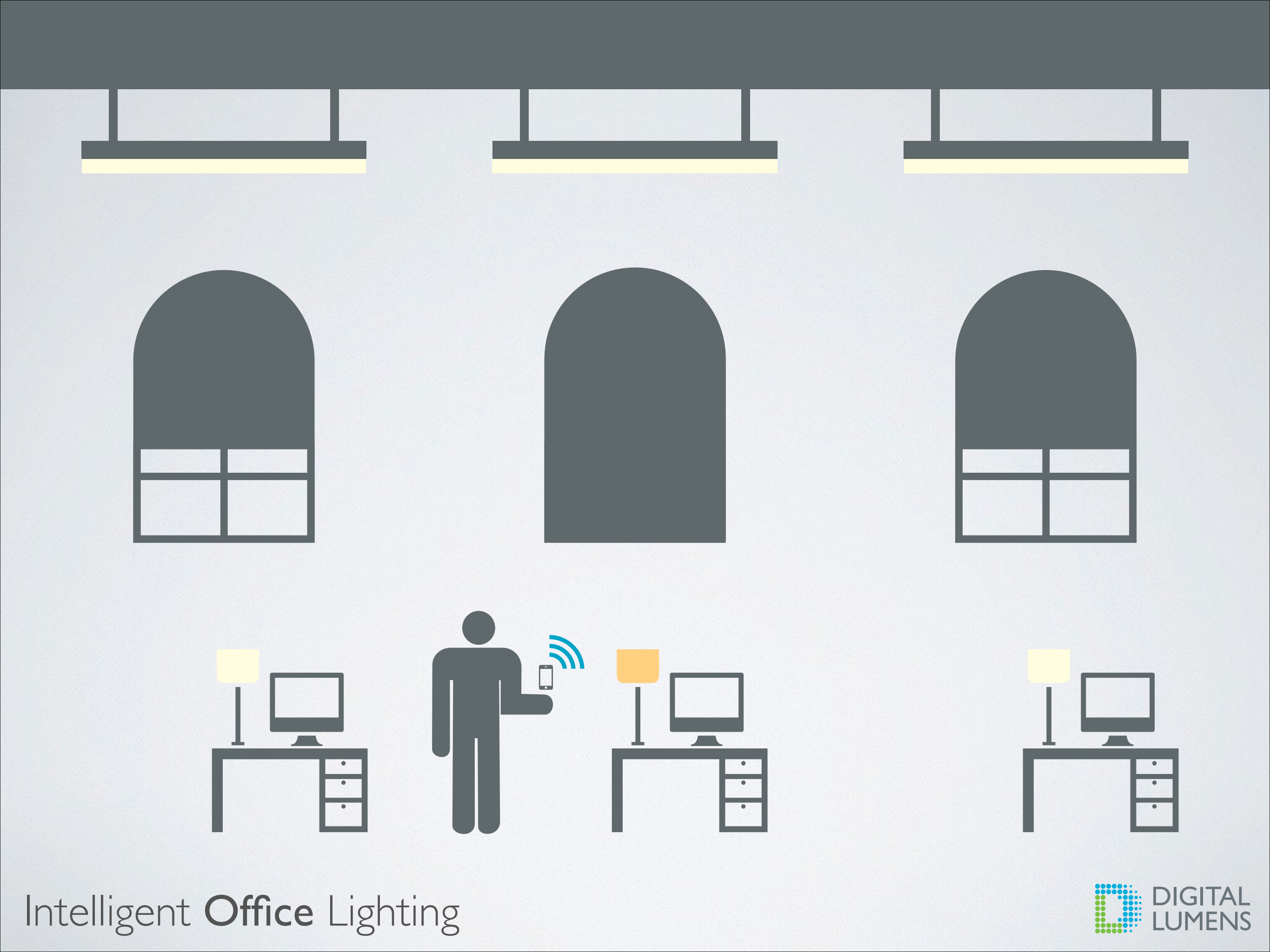
Energy Savings & Productivity

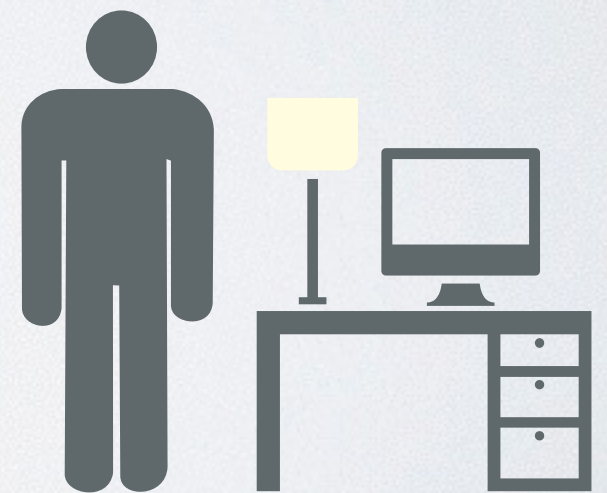
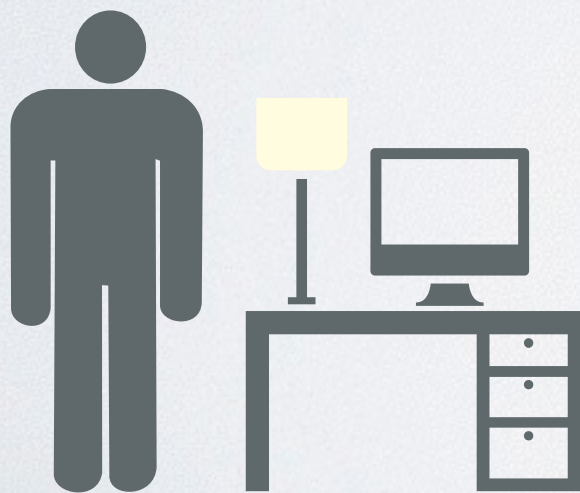
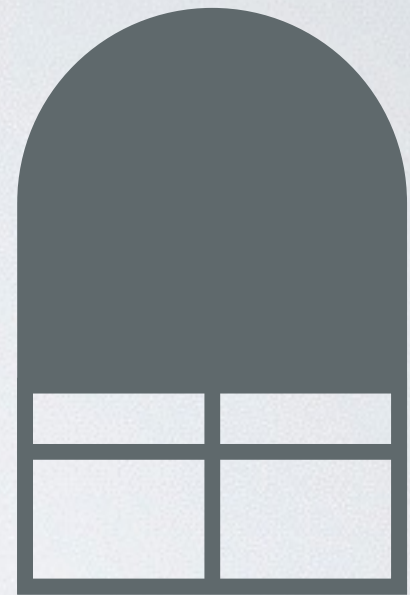
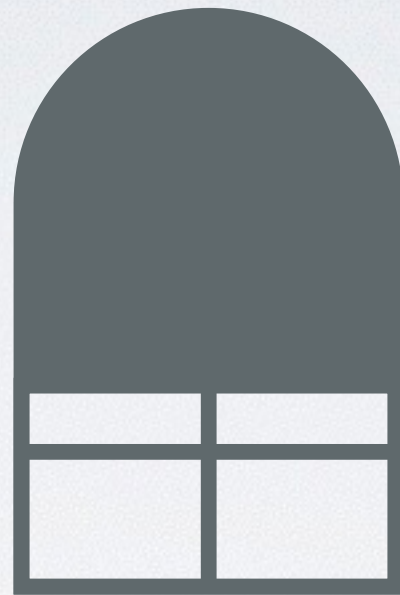
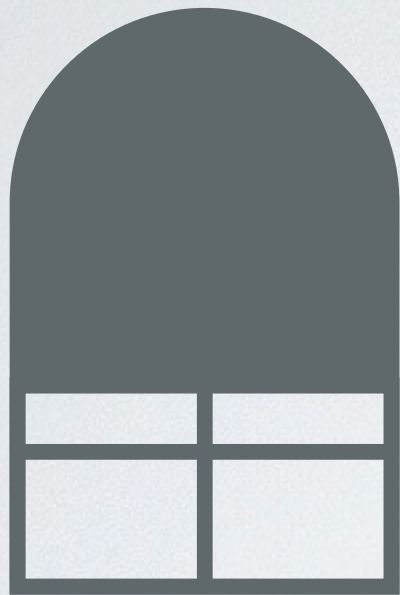
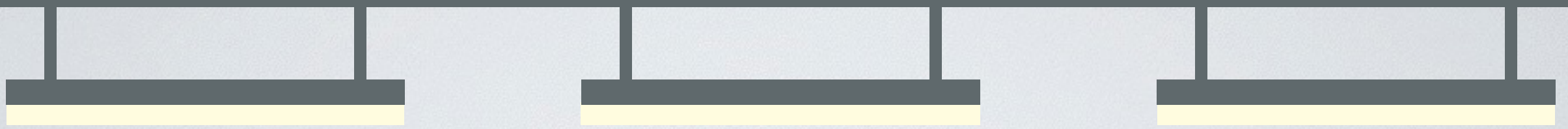


Office

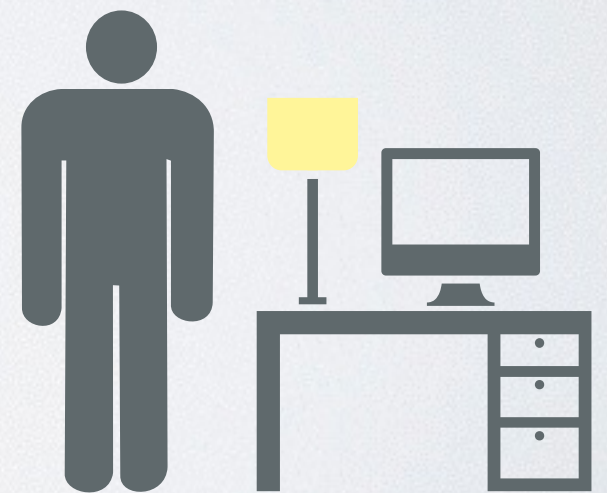
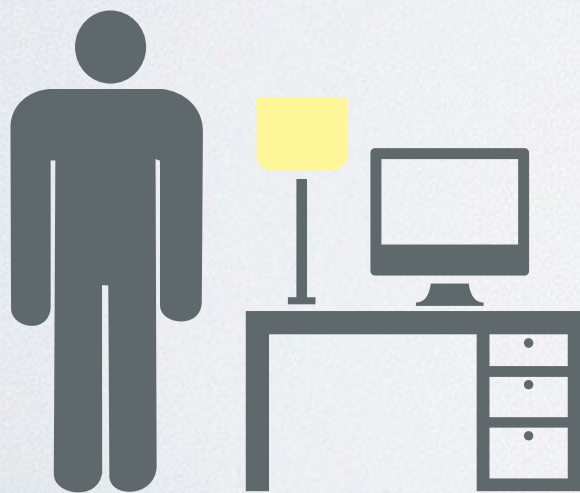
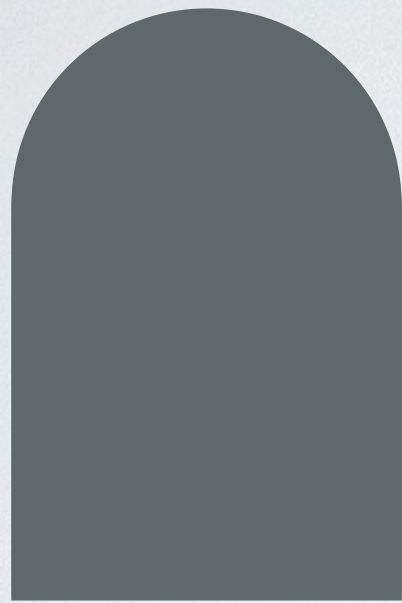
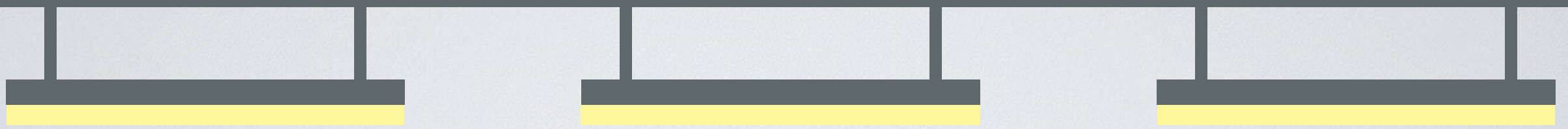




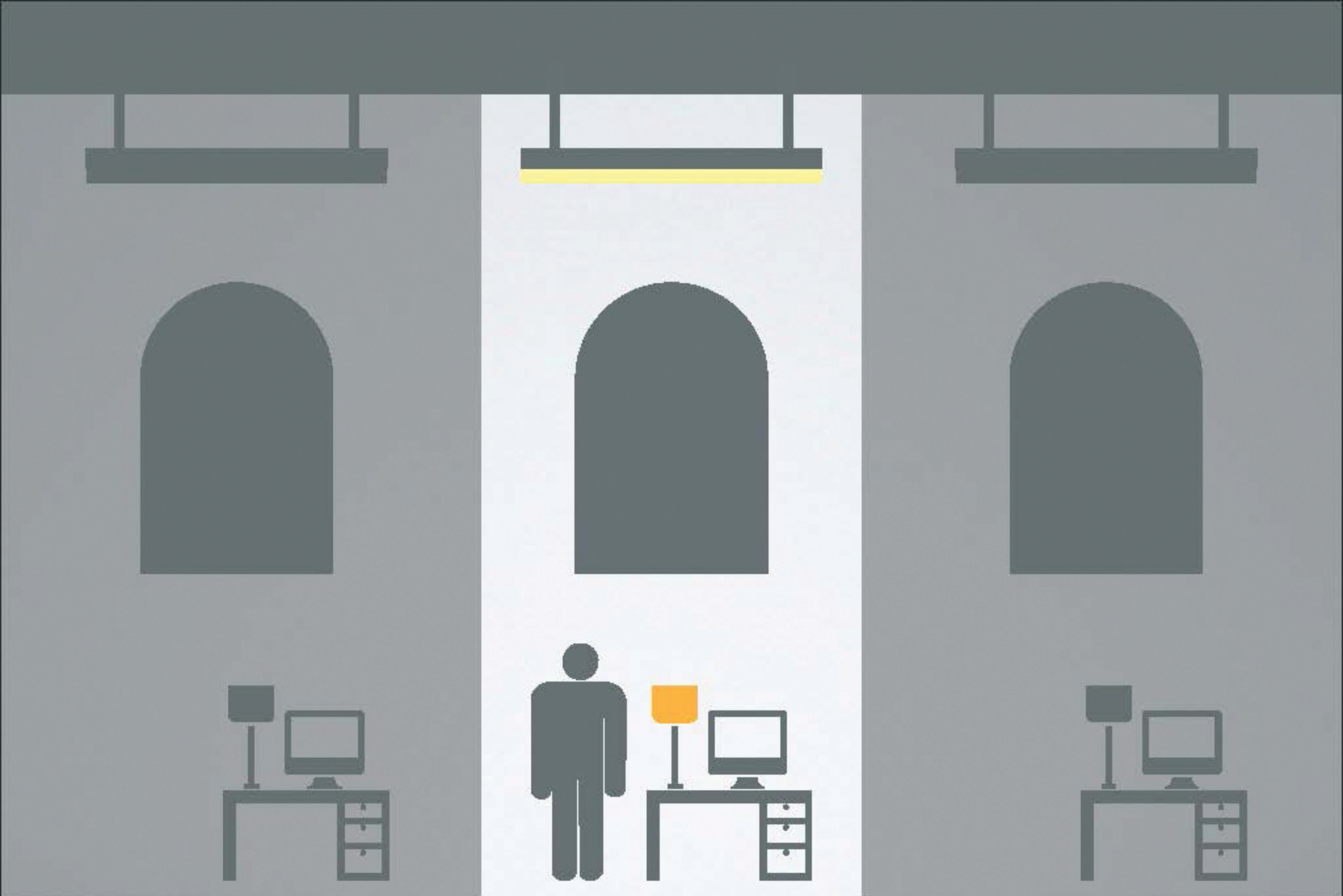




Intelligent **Office** Lighting



Intelligent **Office** Lighting



Intelligent **Office** Lighting

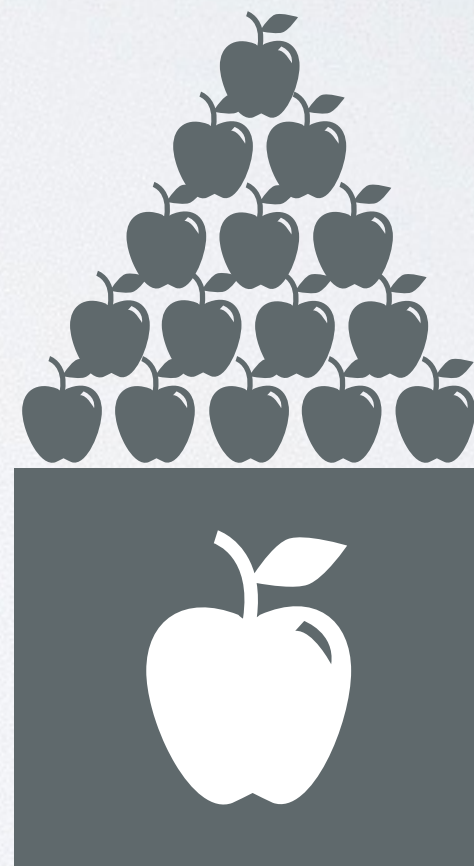
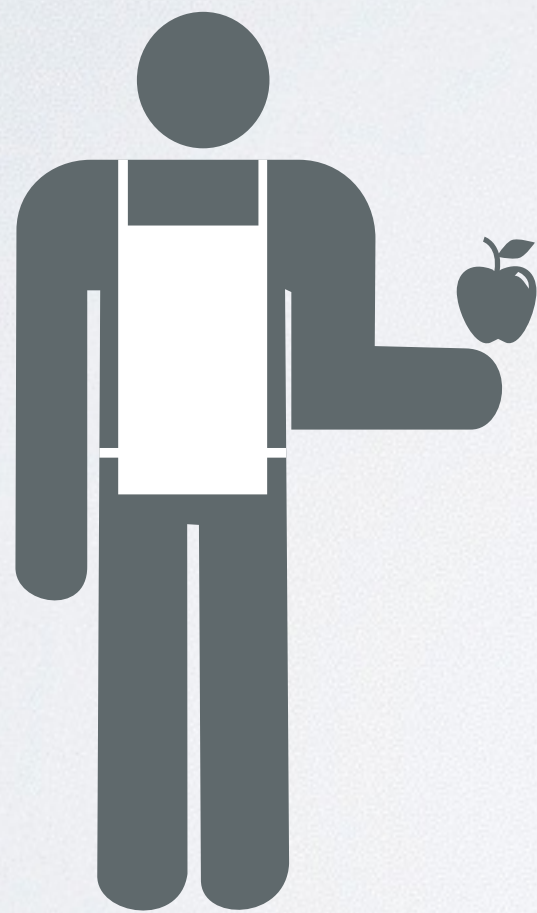
Intelligent **Office** Lighting
to enhance

Comfort & Productivity

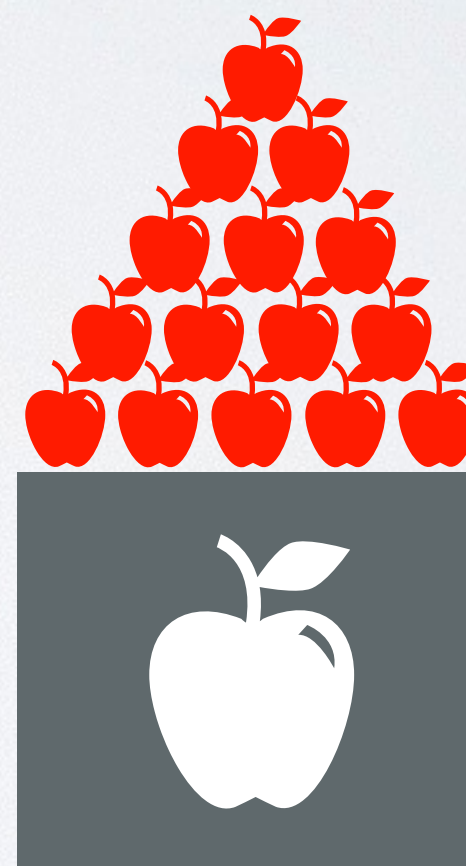
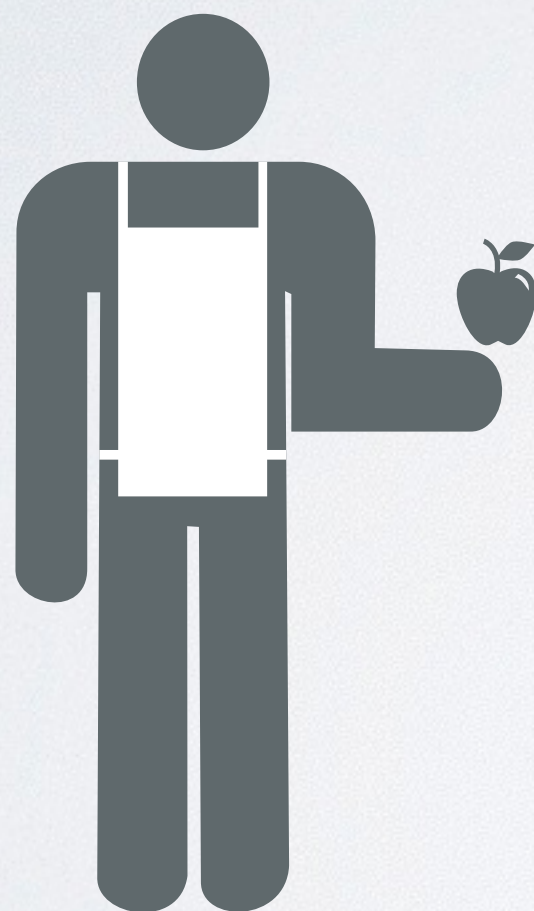


Retail

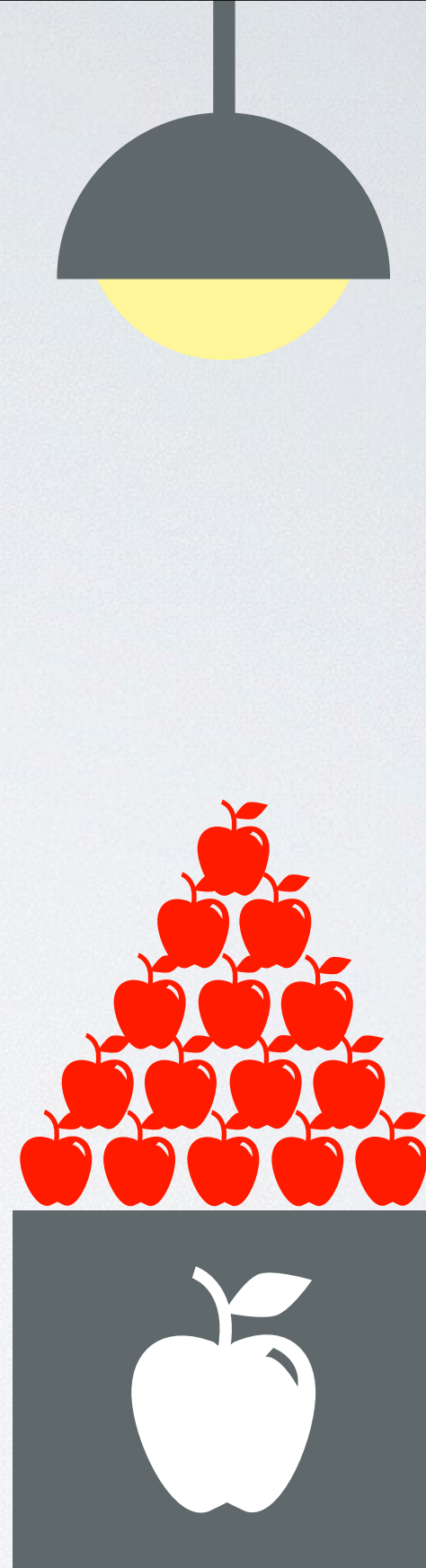
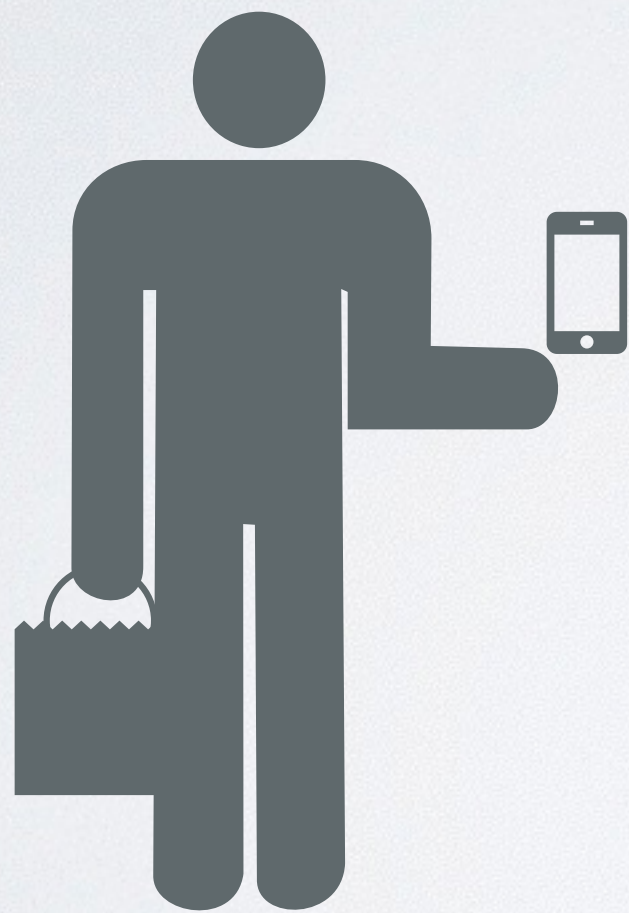




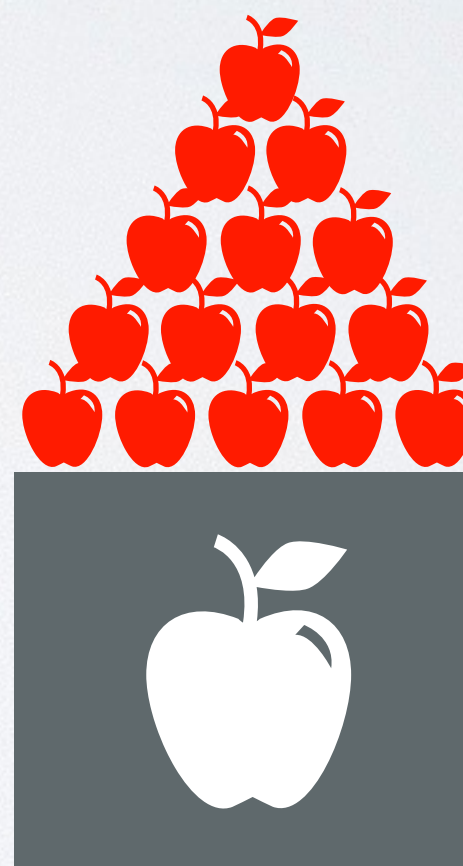
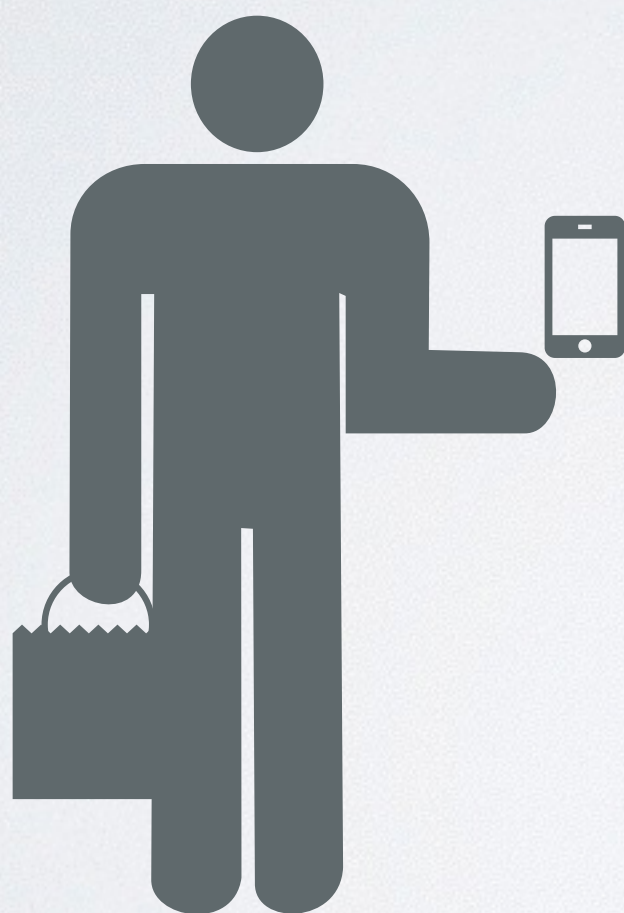
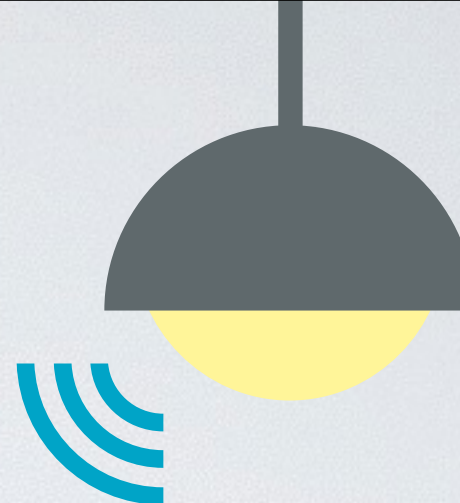
Intelligent **Retail** Lighting



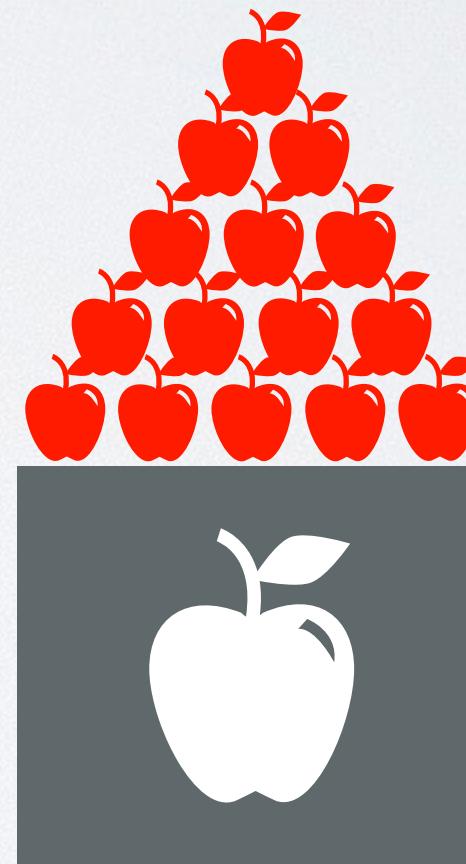
Intelligent **Retail** Lighting



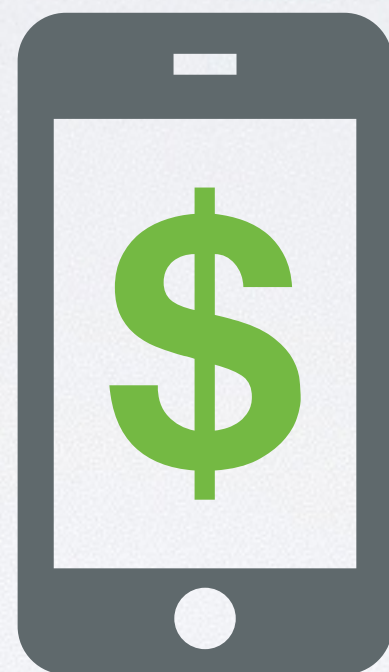
Intelligent **Retail** Lighting



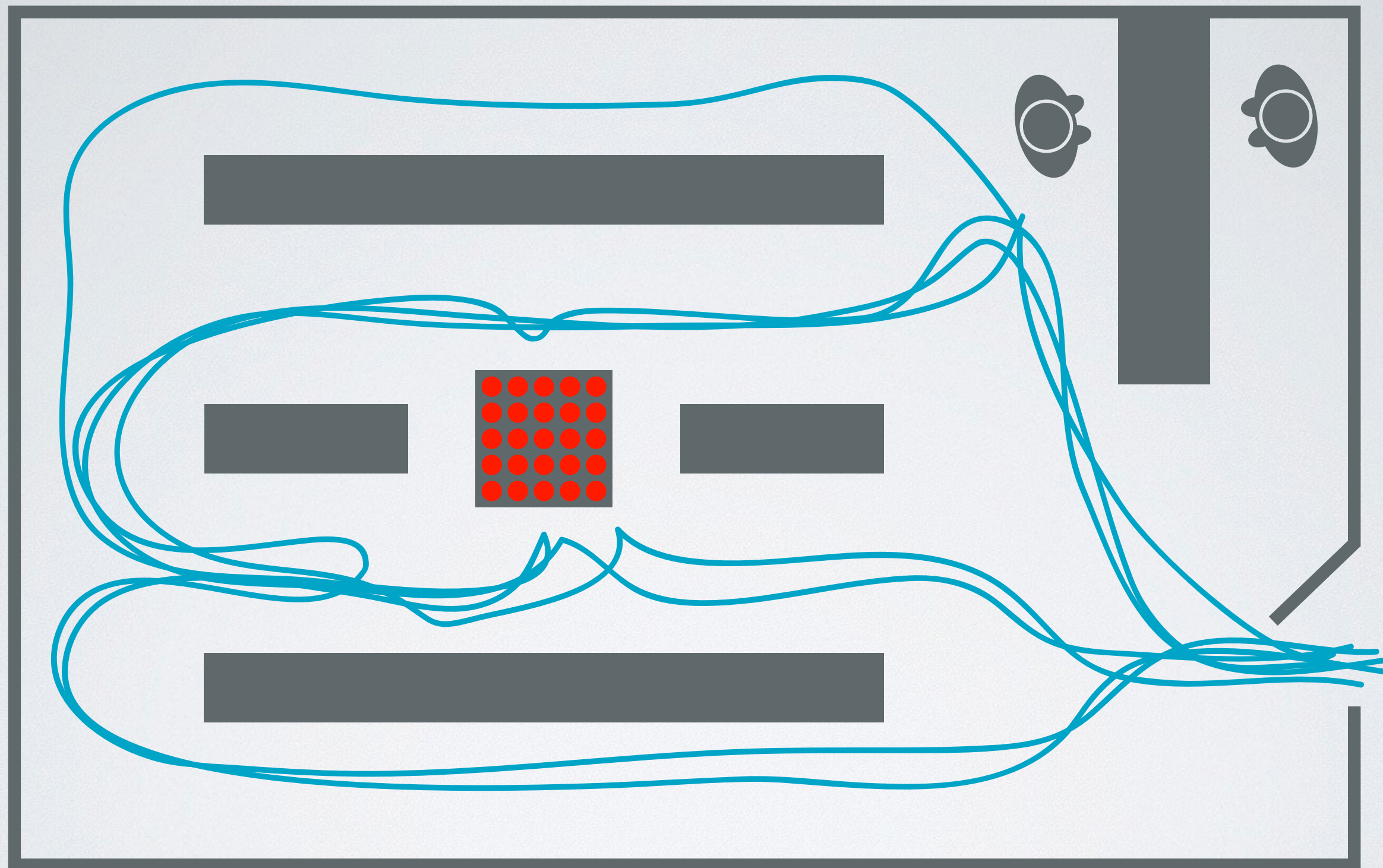
Intelligent **Retail** Lighting



Intelligent **Retail** Lighting



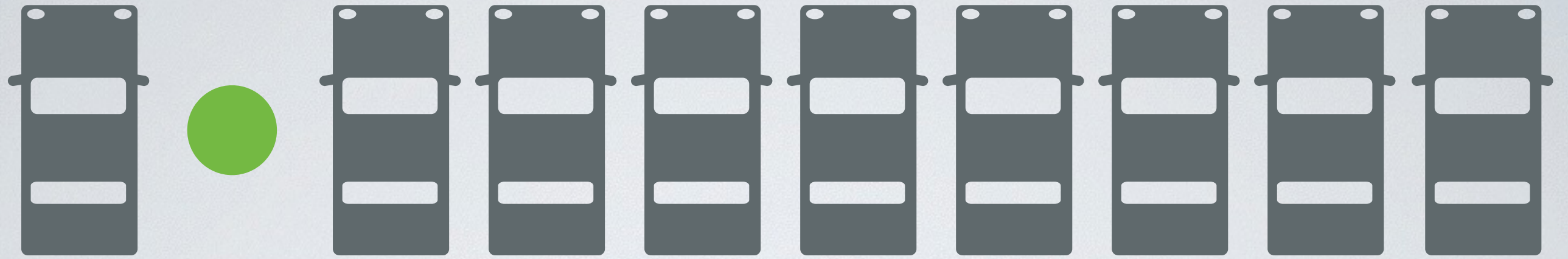
Intelligent **Retail** Lighting



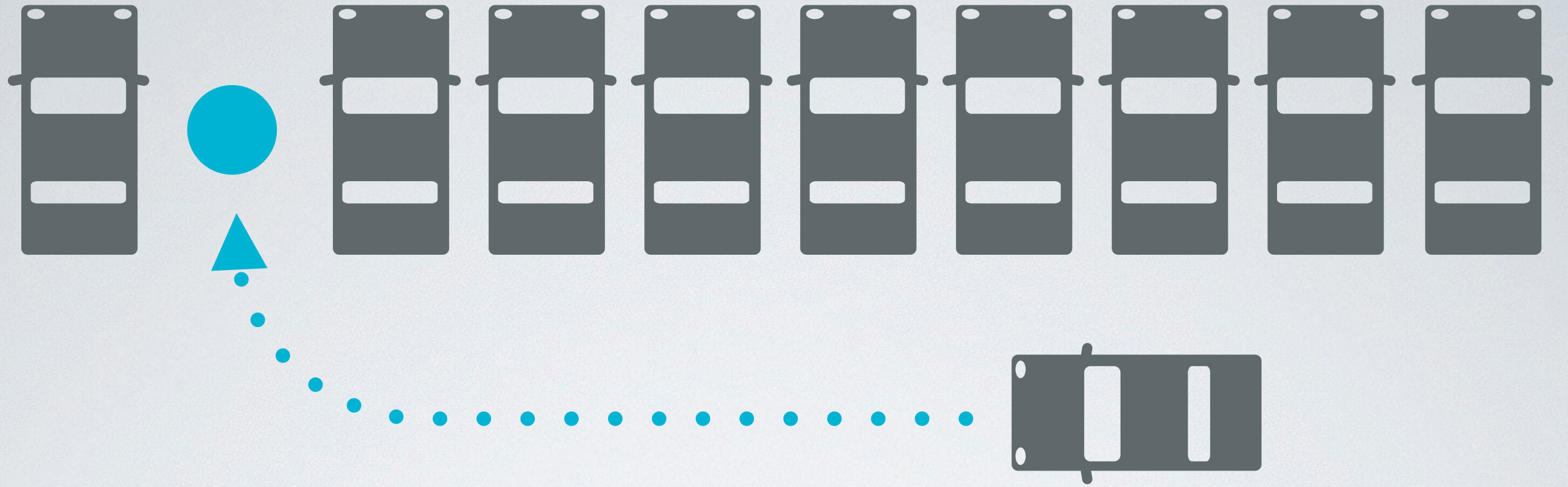
Intelligent **Retail** Lighting
to enhance

Sales & Merchandising

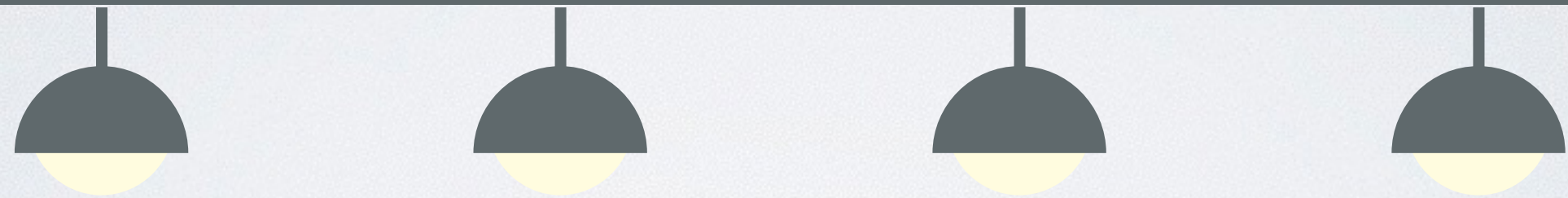




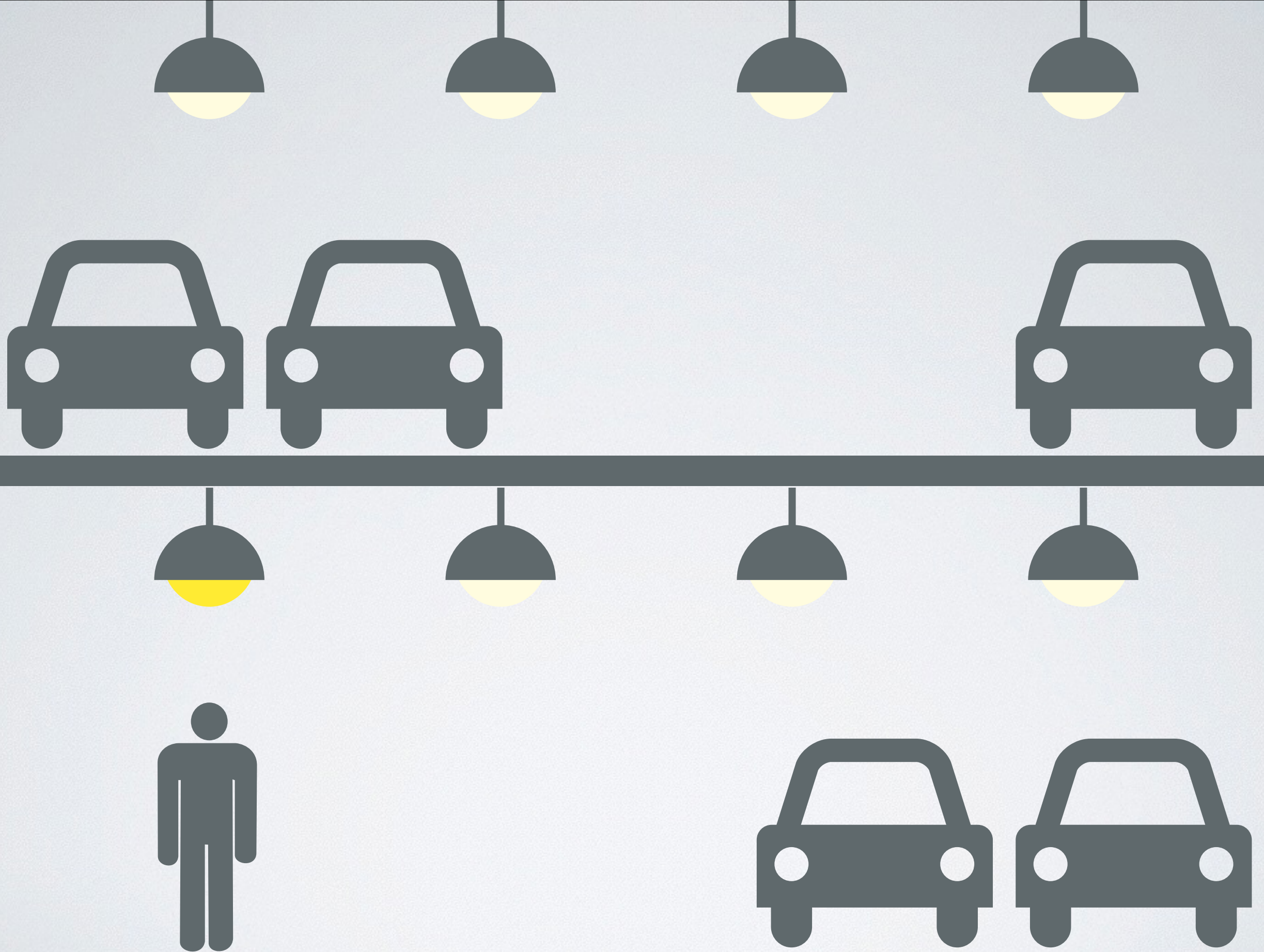
Intelligent **Parking Garage** Lighting



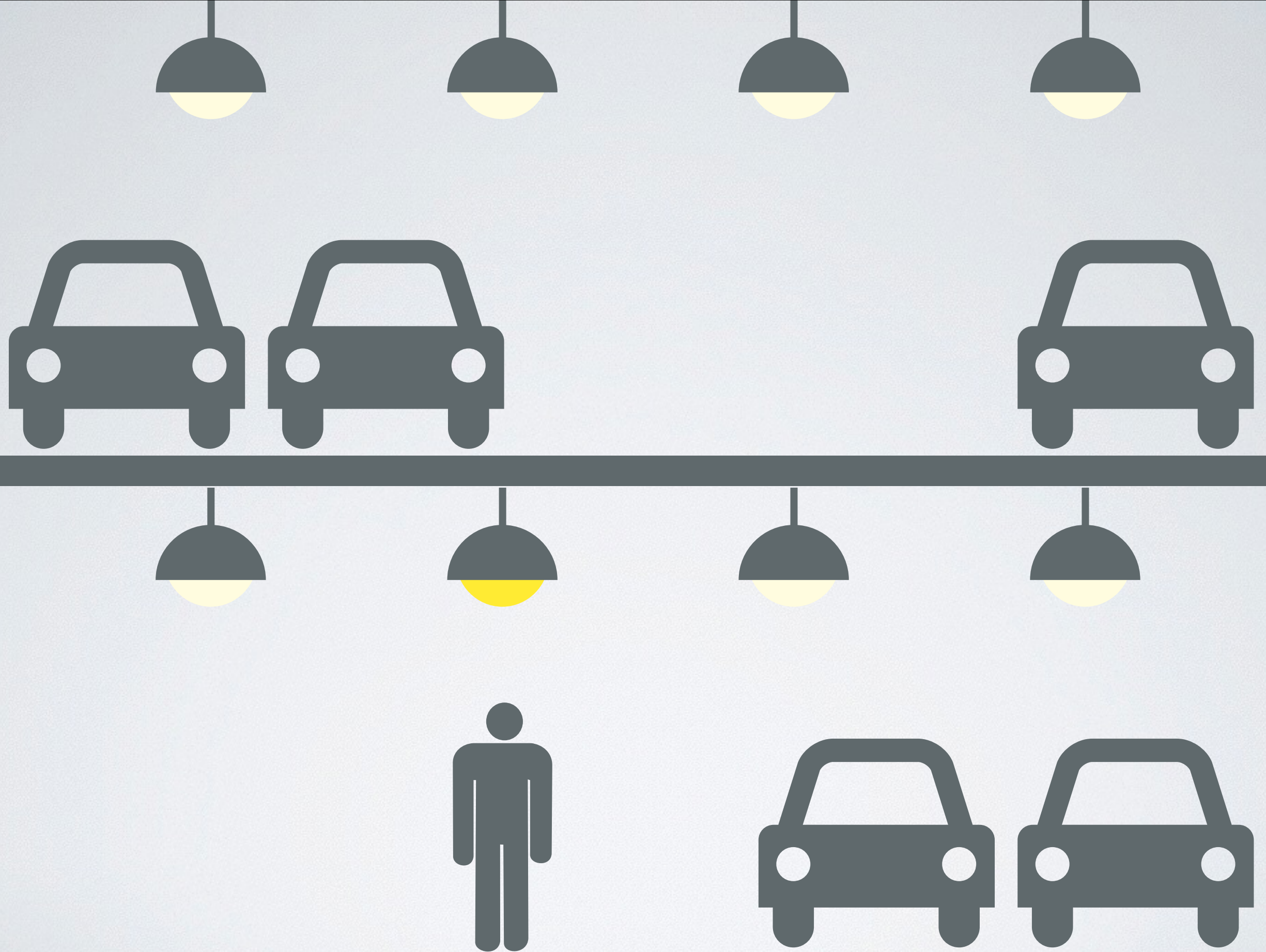
Intelligent **Parking Garage** Lighting



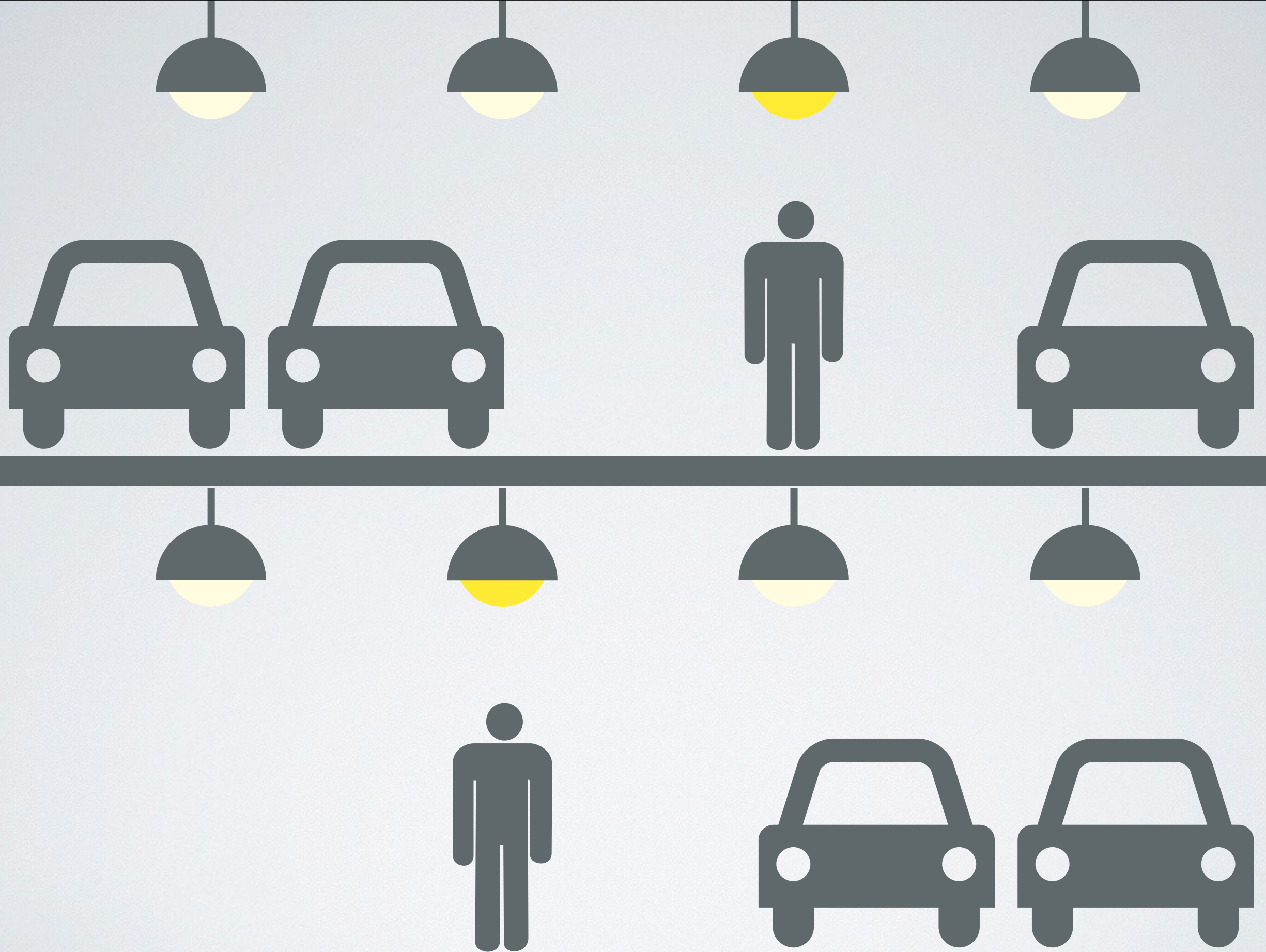
Intelligent **Parking Garage** Lighting



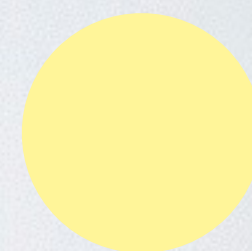
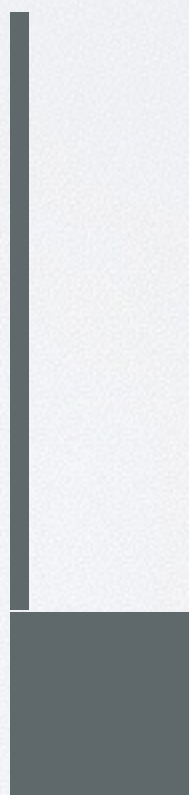
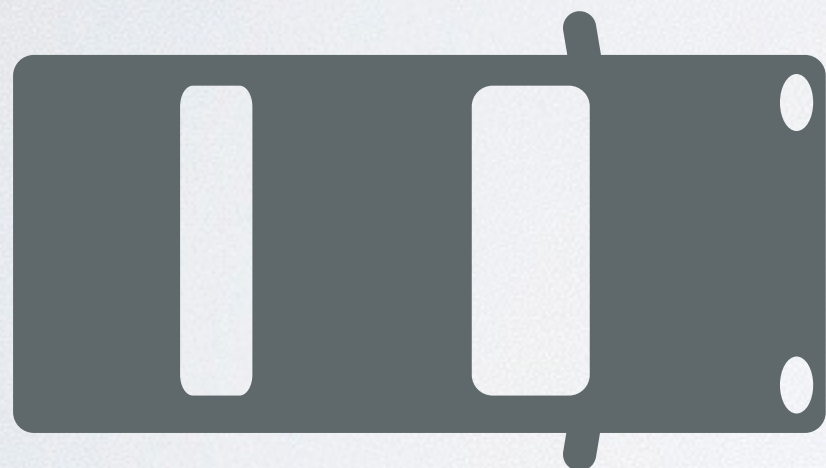
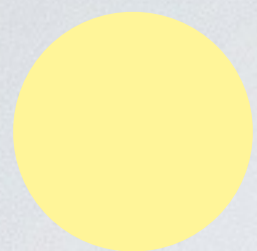
Intelligent **Parking Garage** Lighting



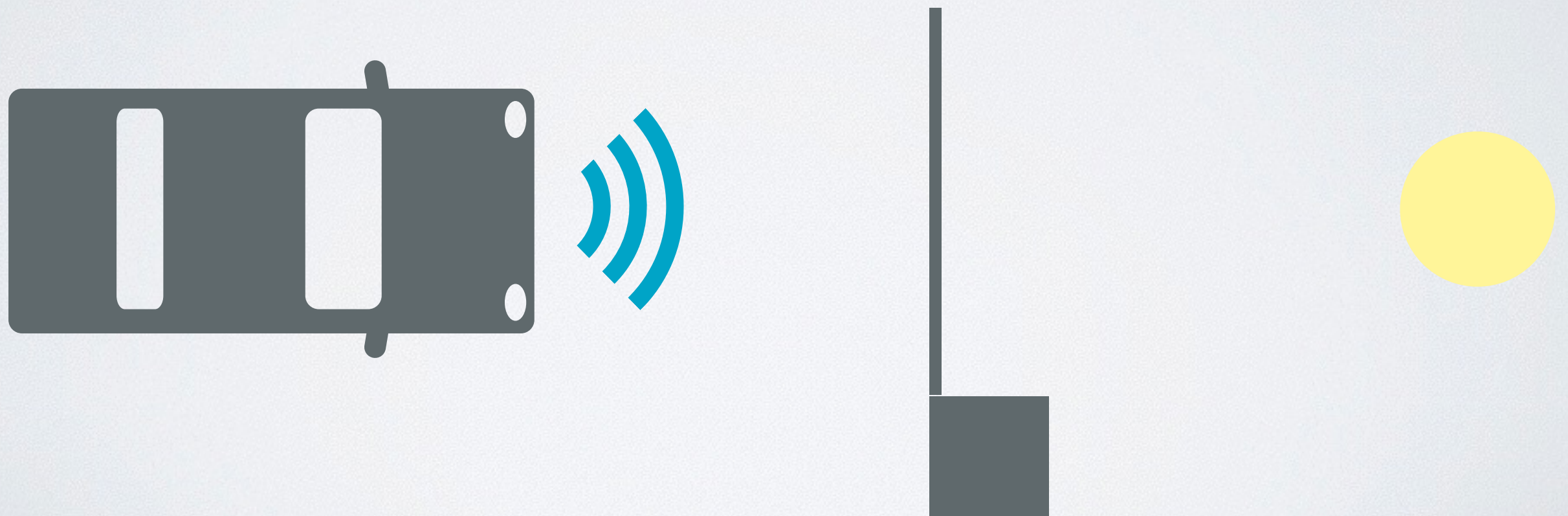
Intelligent **Parking Garage** Lighting



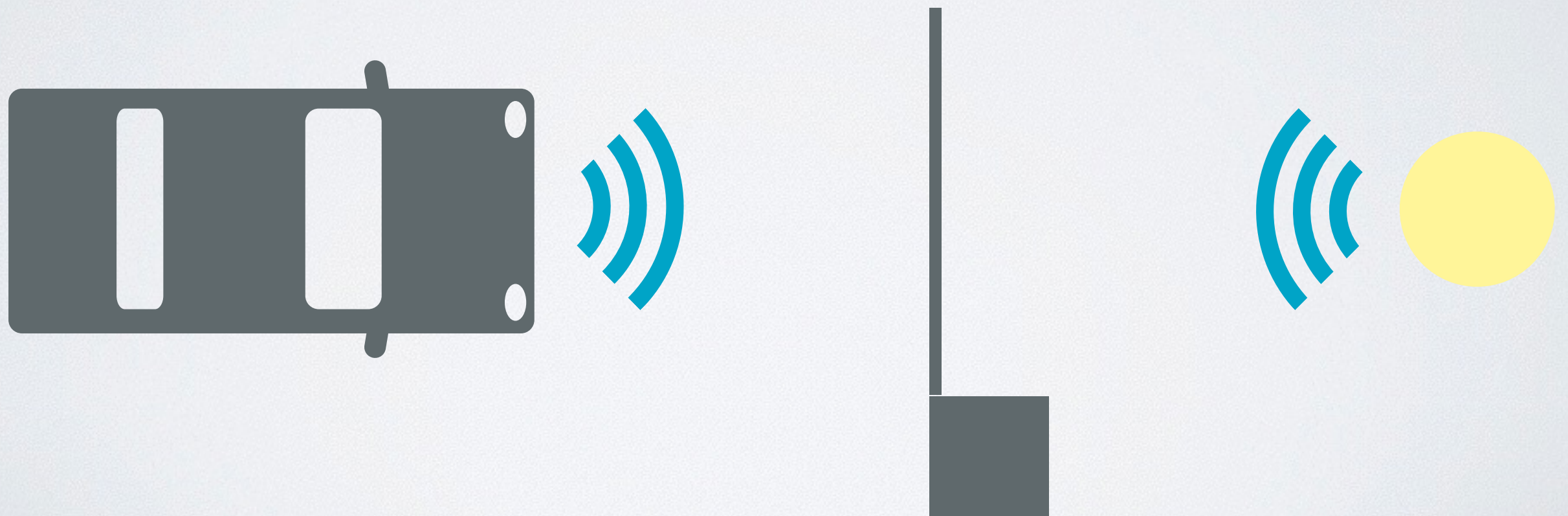
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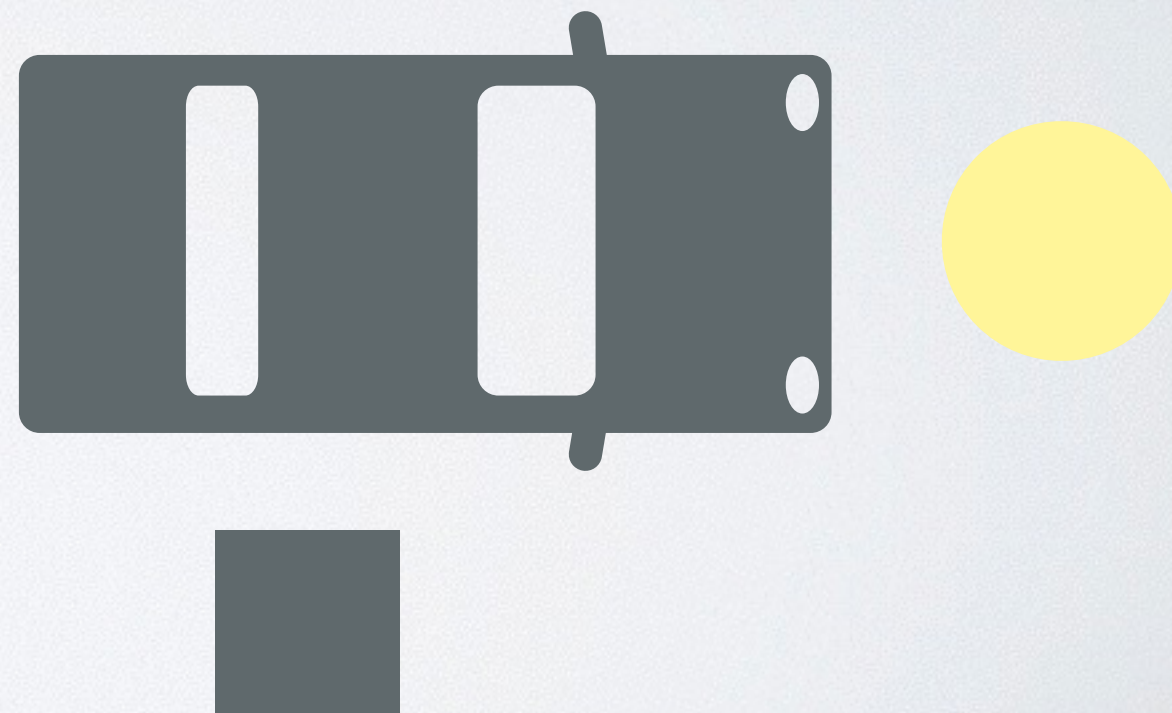
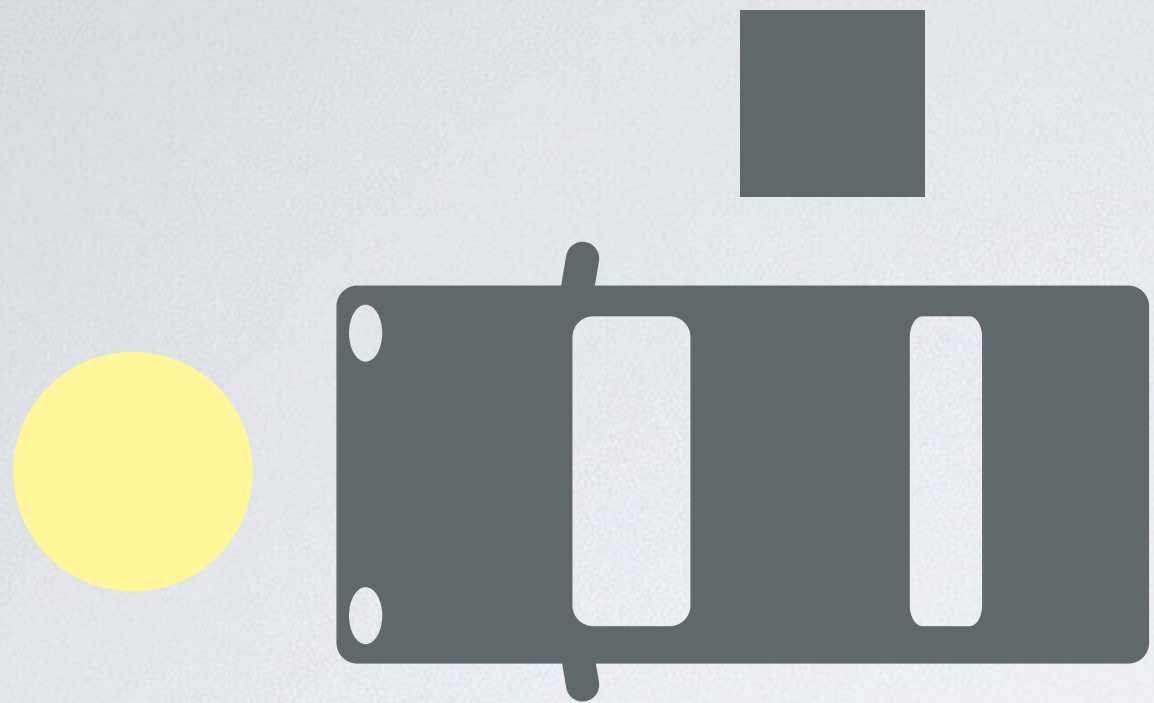
Intelligent **Parking Garage** Lighting



Intelligent **Parking Garage** Lighting



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Intelligent **Parking Garage** Lighting

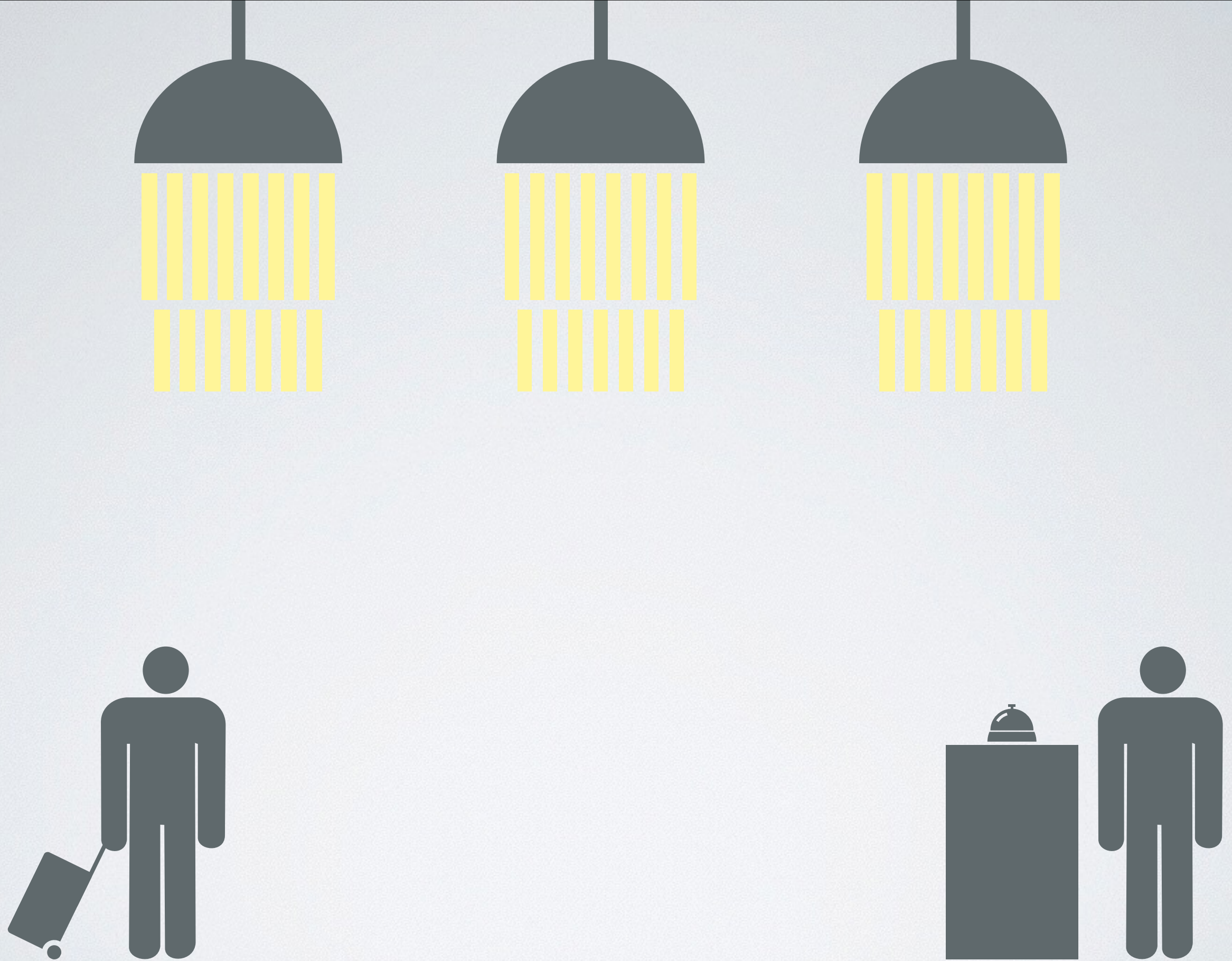
Intelligent **Parking Garage** Lighting
to enhance

Safety & Revenue

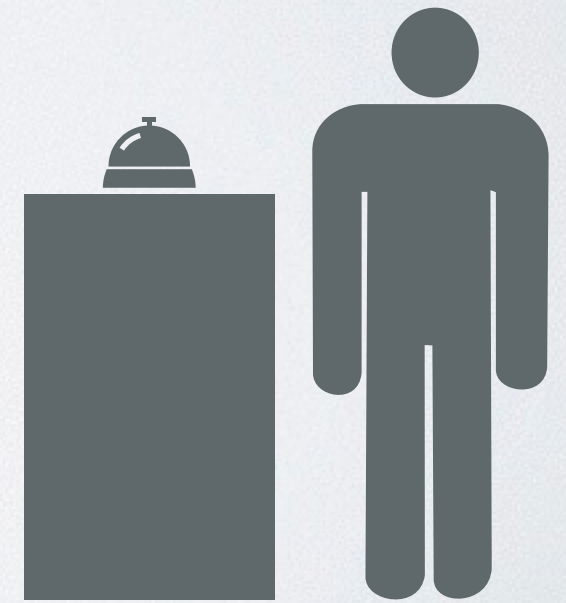
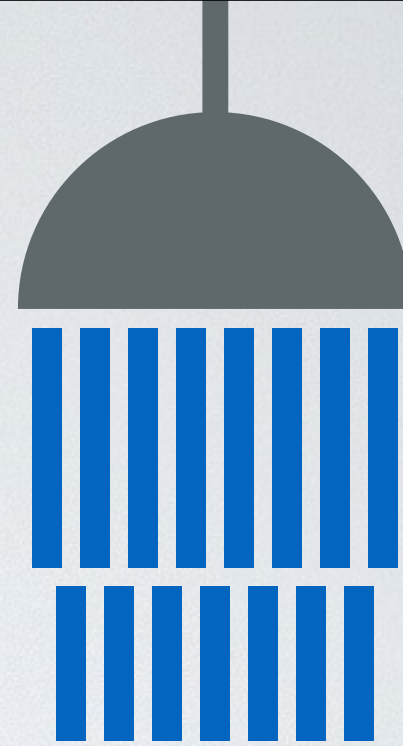
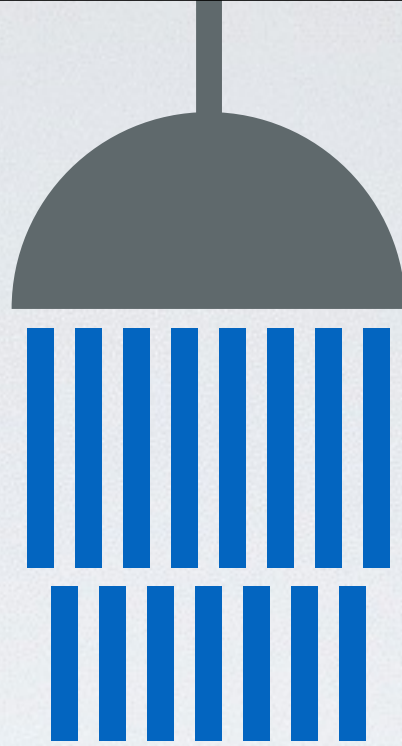
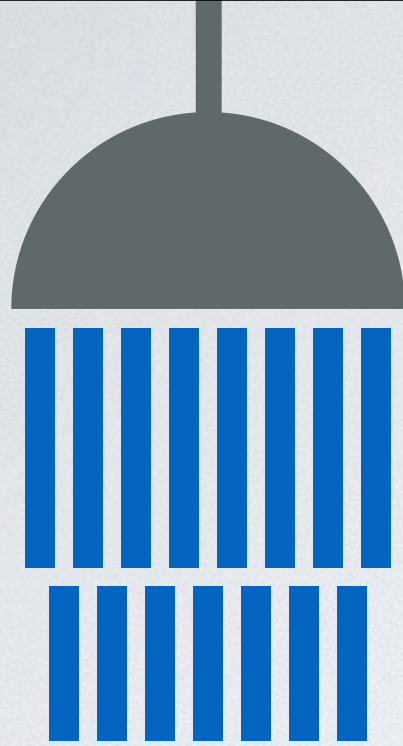




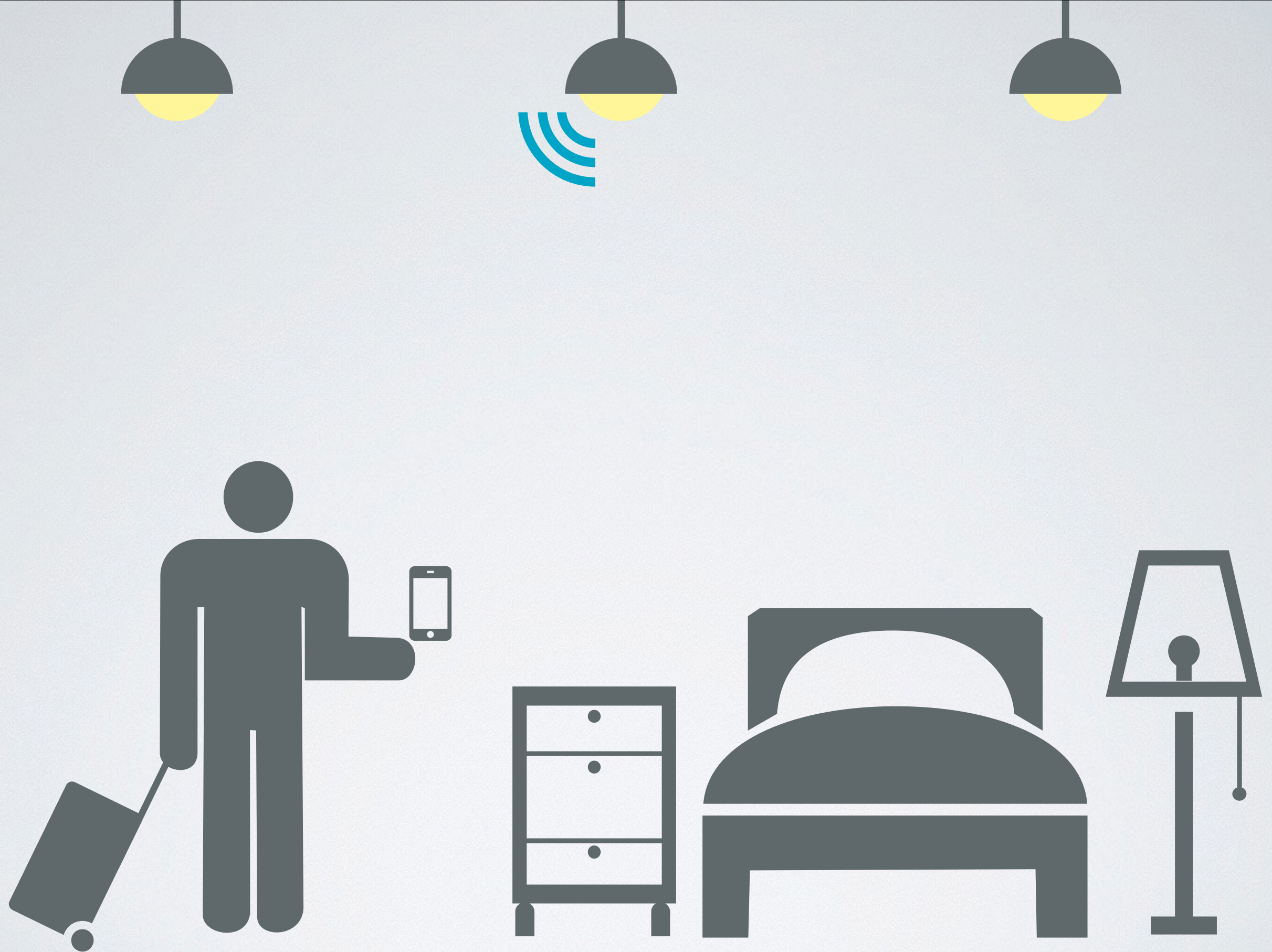
Intelligent **Hospitality** Lighting



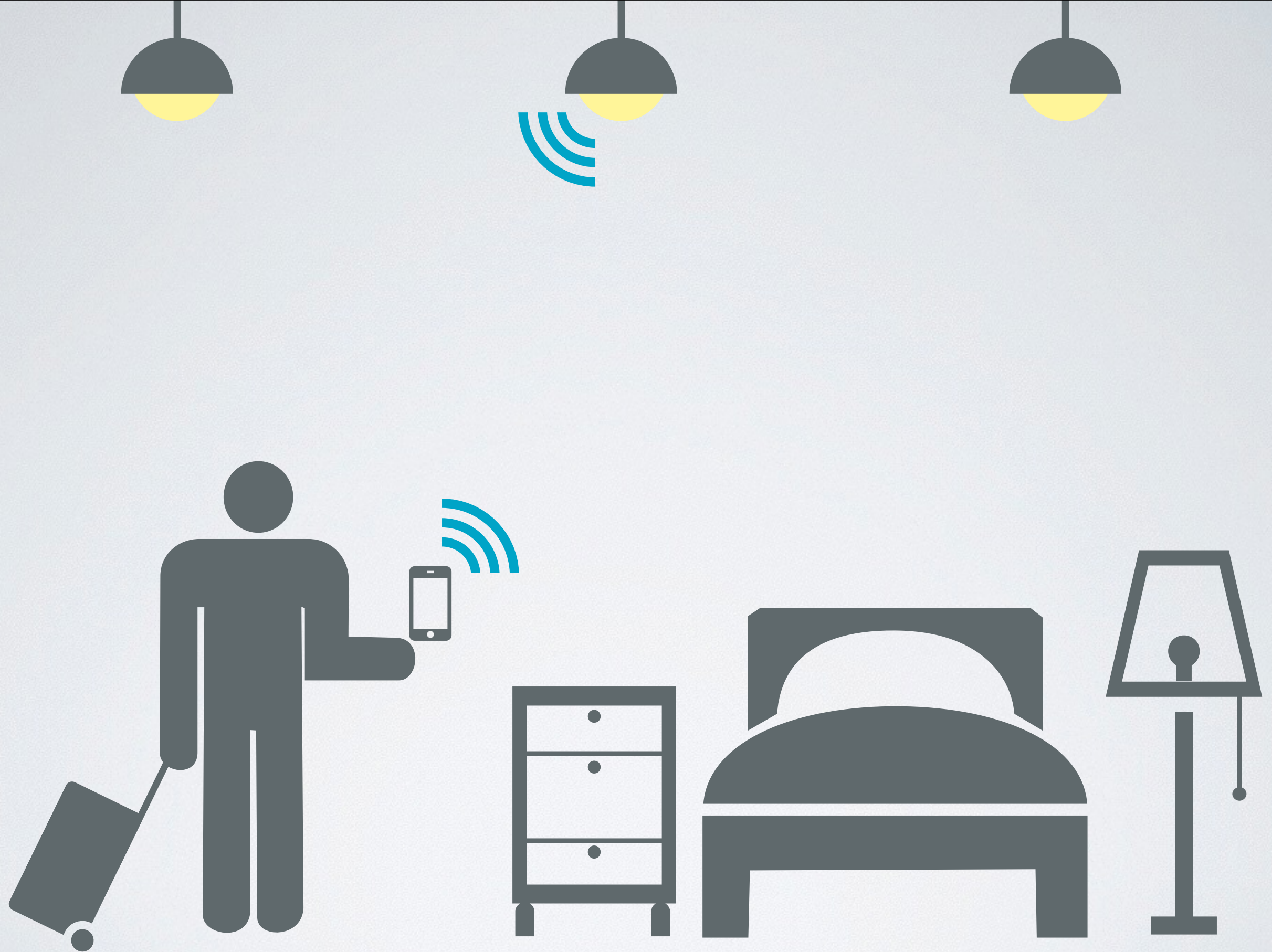
Intelligent **Hospitality** Lighting



Intelligent **Hospitality** Lighting



Intelligent **Hospitality** Lighting



Intelligent **Hospitality** Lighting



Intelligent **Hospitality** Lighting

Intelligent **Hospitality** Lighting
to enhance

Comfort & Brand





Intelligent **Residential** Lighting



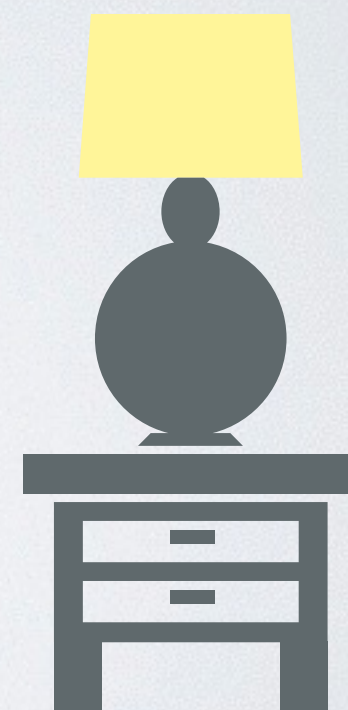
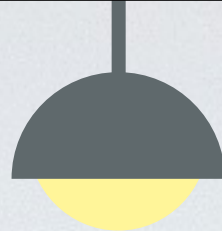
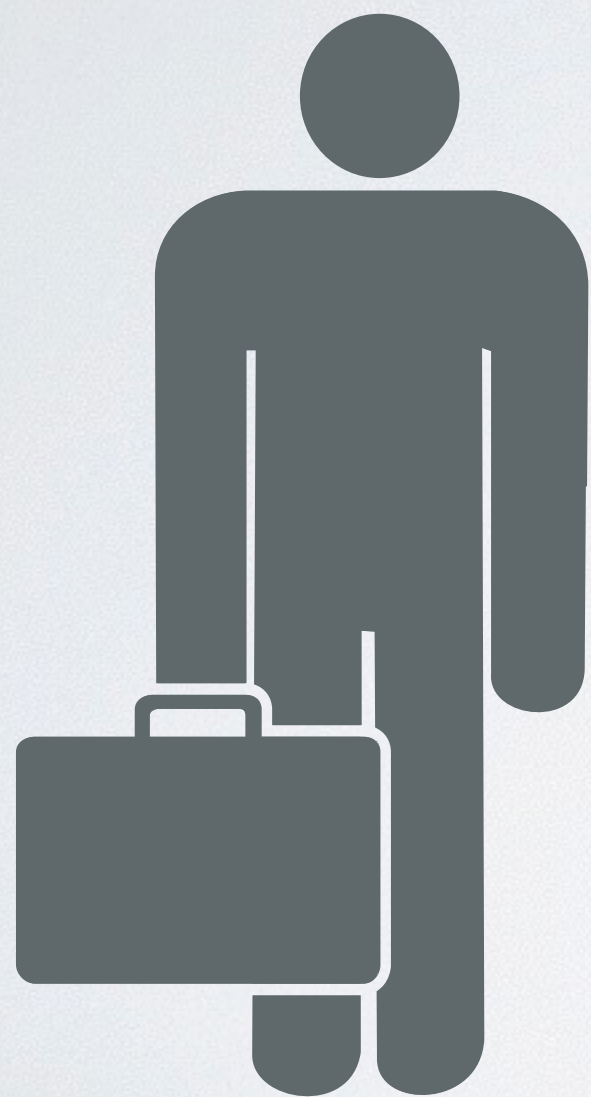
Intelligent **Residential** Lighting



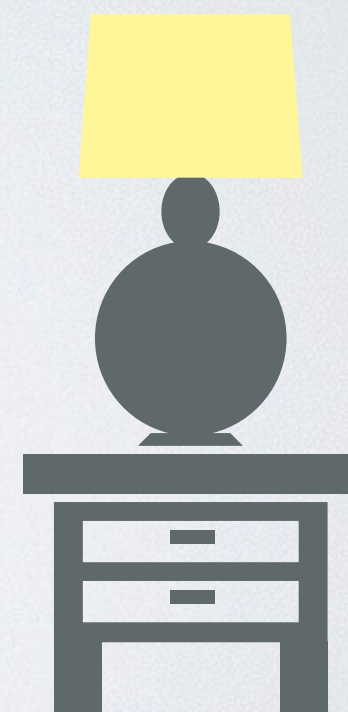
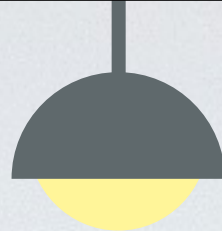
Intelligent **Residential** Lighting



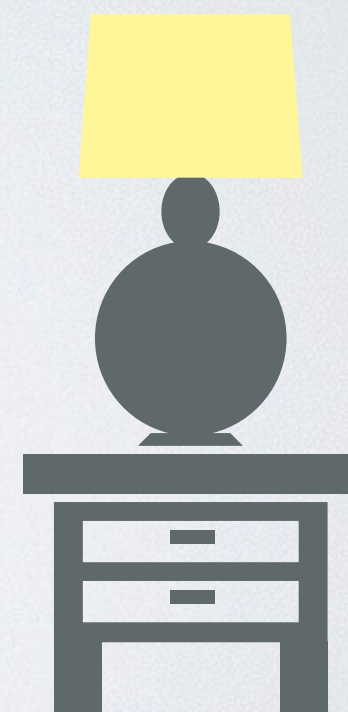
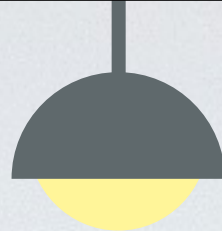
Intelligent **Residential** Lighting



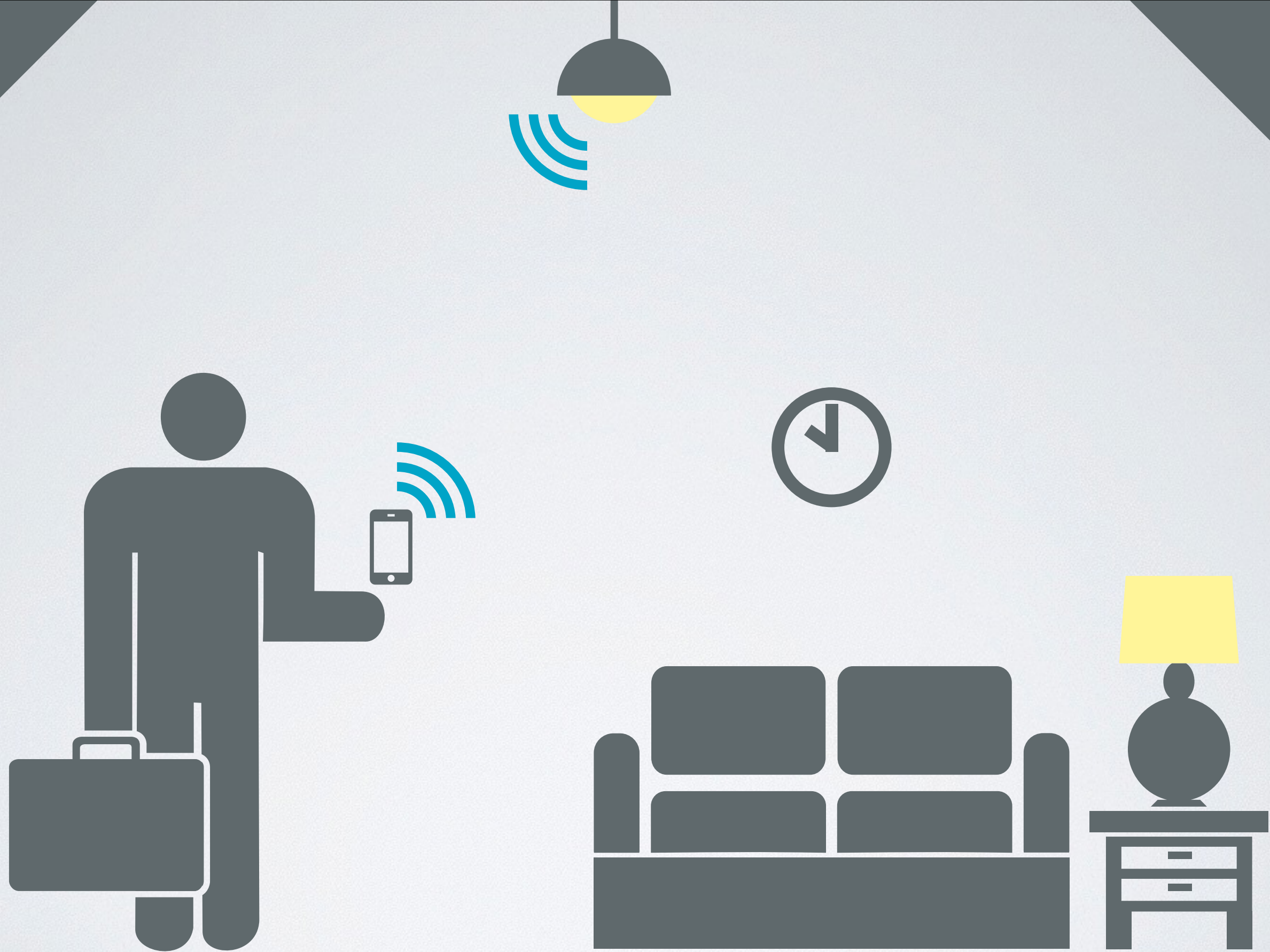
Intelligent **Residential** Lighting



Intelligent **Residential** Lighting



Intelligent **Residential** Lighting



Intelligent **Residential** Lighting



Intelligent Residential Lighting

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Intelligent **Residential** Lighting
to enhance

Safety & Comfort

What do all of these stories have in **COMMON?**

The future of lighting is...

DIGITAL

NETWORKED

PERSONALIZED

ENERGY-AWARE

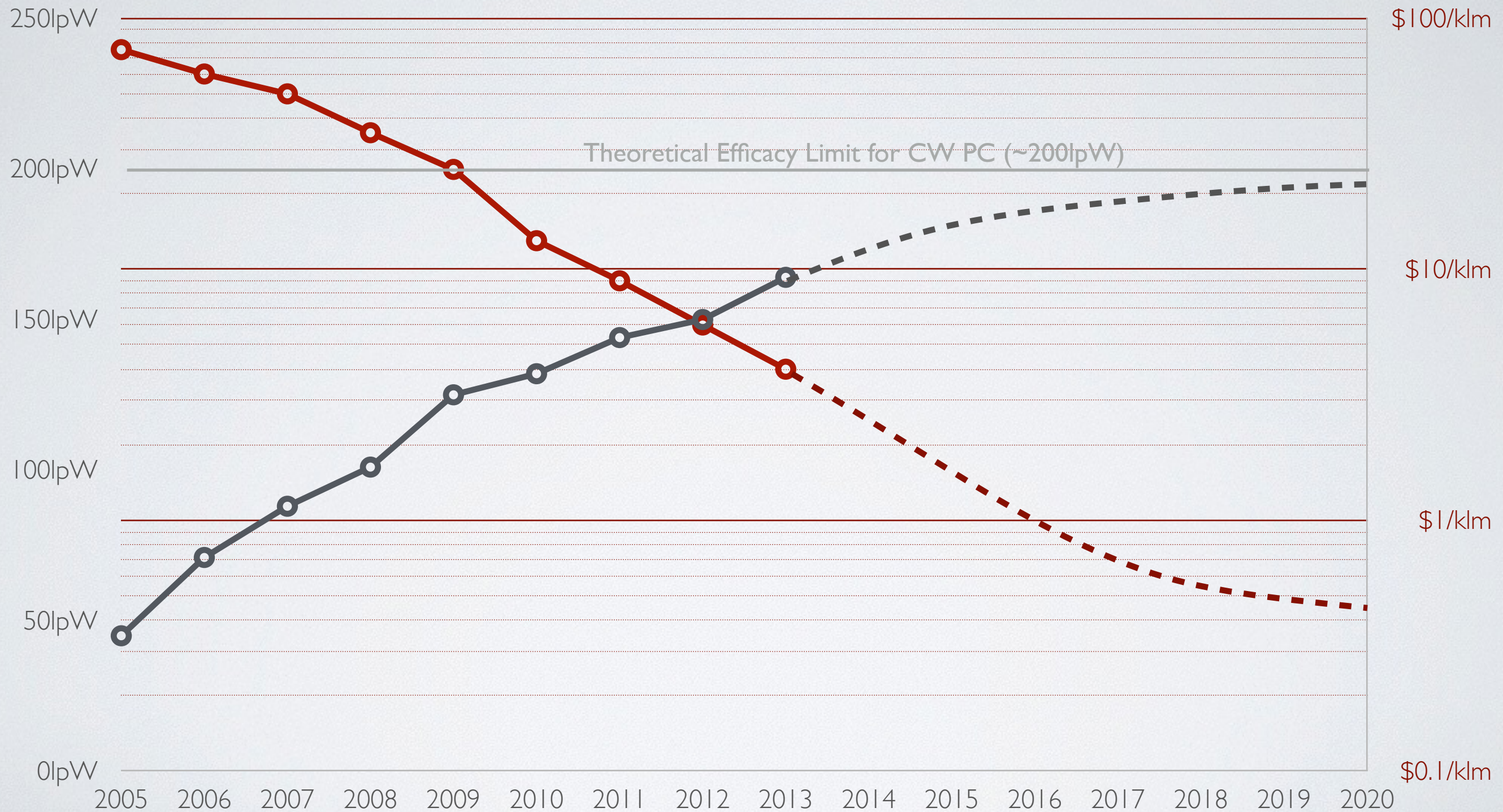
RESPONSIVE

3.

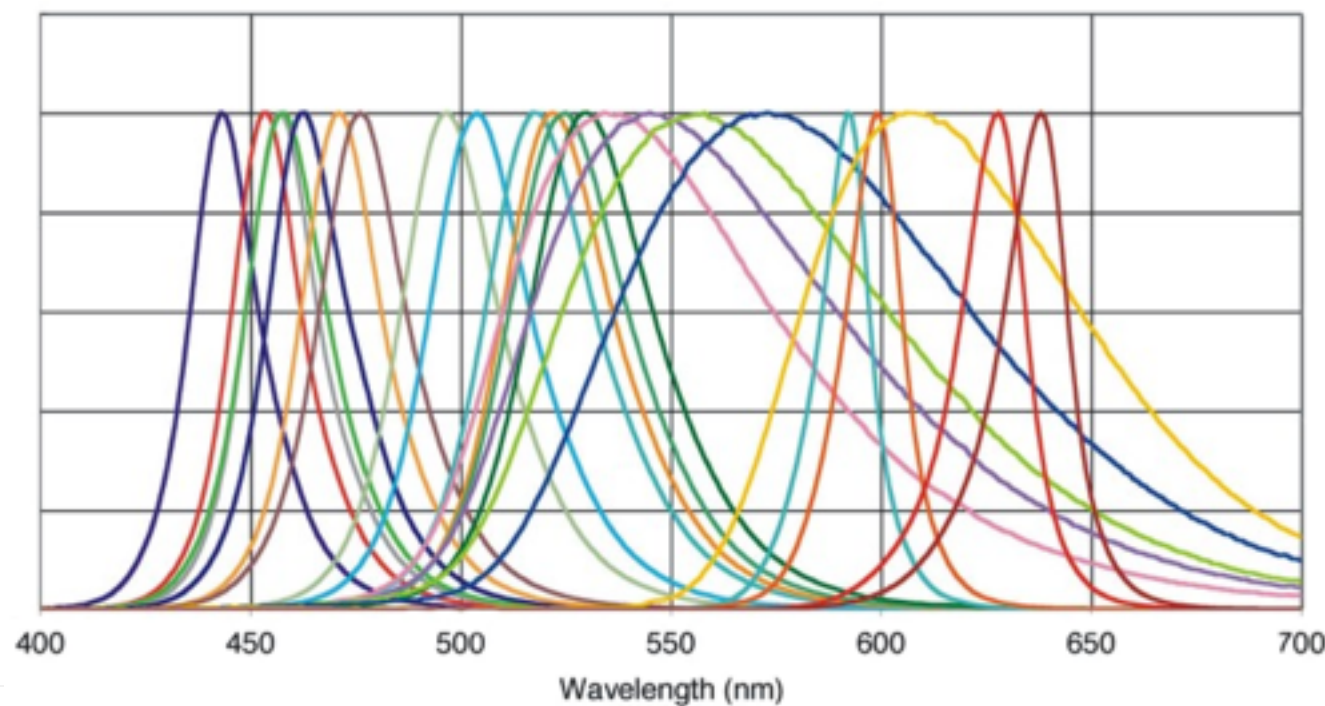
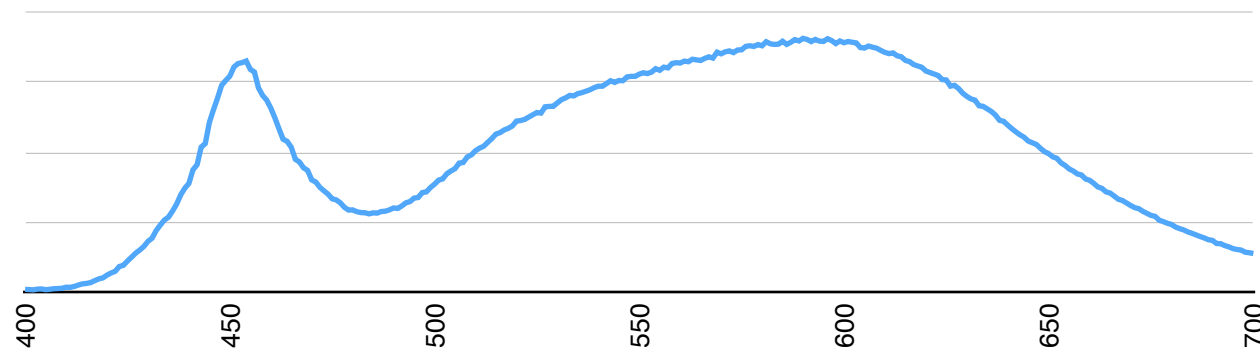
How do we get there?

(R&D priorities for intelligent lighting)

Price & Performance

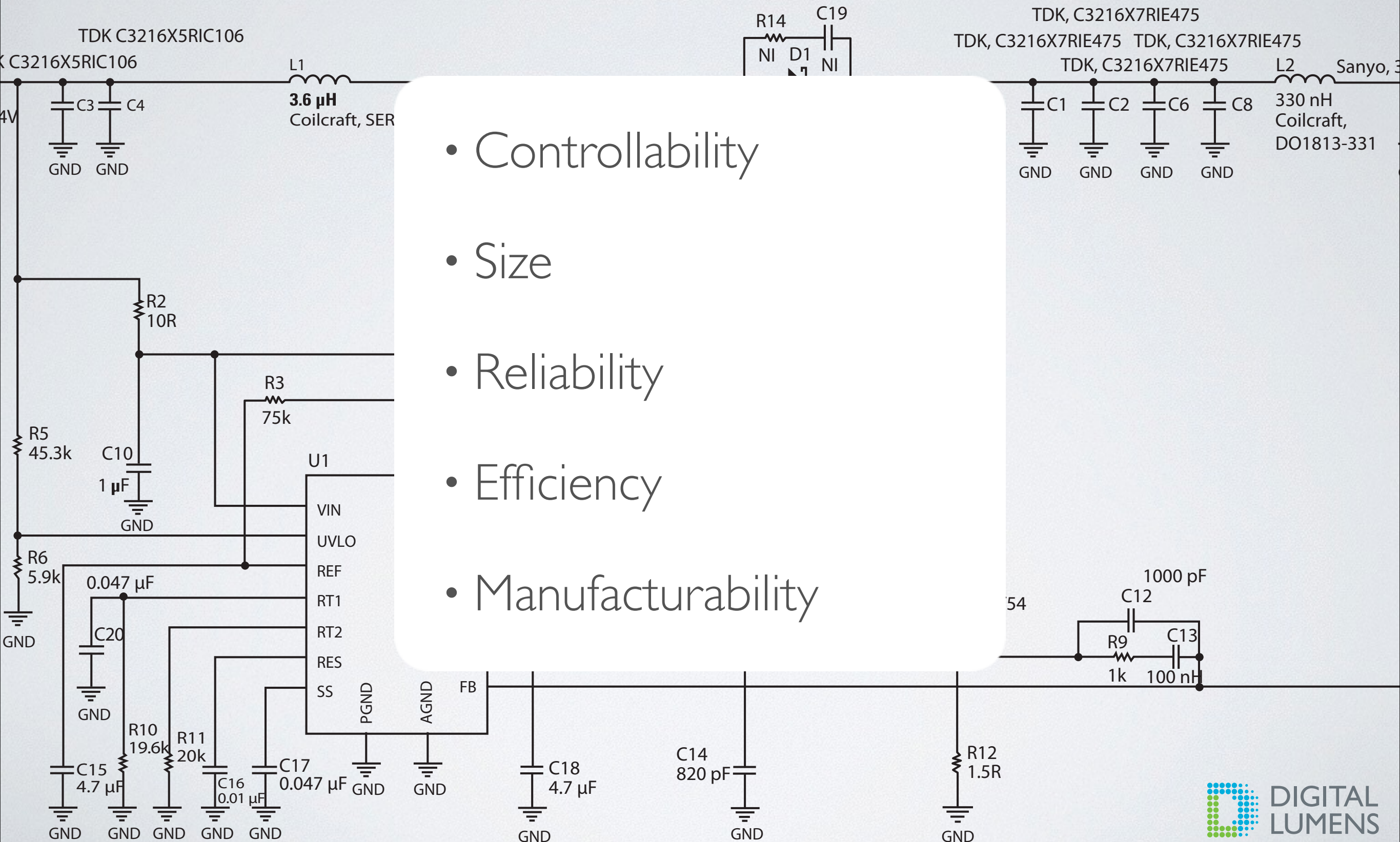


Full Spectrum Sources



- Higher theoretical efficacy limit
- Photobiological optimization
 - People
 - Plants
 - Livestock

Digital Power Topologies



- Controllability
- Size
- Reliability
- Efficiency
- Manufacturability

Deep System Integration



- Personalization
- Making data actionable
- Closing the loop





DIGITAL
LUMENS

Thank You!

Email: bchemel@digitallumens.com



: [@bchemel](https://twitter.com/bchemel)